UNEP

Enhancing Information for Renewable Energy Technology Deployment in Brazil, China, and South Africa

United Nations Energy Programme

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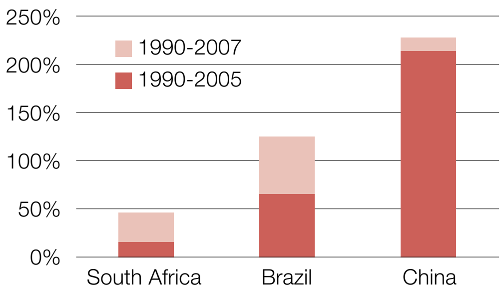
EXECUTIVE SUMMARY

Greenhouse gas emissions from Big Emerging Markets, BEM, will likely exceed those from developed countries within the next 20 years, stressing the need for emerging markets efforts to reduce the risk of climate change (Solomon, 2007). At the same time, the Big Emerging Markets and their allies have called for a commitment to extending Kyoto but are reluctant to accept legally binding emissions reduction targets.

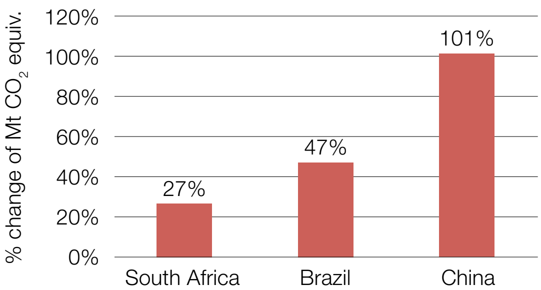
Brazil, China and South Africa – three of the key Big Emerging Markets – are rapidly increasing their energy consumption, with the energy sector contributing the most to their emissions, 20%, 65% and 71% respectively. To date, Brazil, China and South Africa have relied primarily on coal and/or large hydropower generation and exploit an insignificant share of their 'total realisable mid-term potentials' for solar and wind energy (IEA, 2009). Therefore, major policy decisions are needed to mobilize public and private resources on a large scale. Energy efficiency measures together with renewable sources of energy could supply the new generating capacity needed to keep pace with these countries economic growth, as all are well endowed with rich renewable energy sources.

Figure 1 Percentage Change in Primary Renewable Energy Consumption



Source: Econsense– Forum for Sustainable Development of German Business

Figure 2 Percentage Change in GHG Emissions From 1990 To 2007



Strong advocates for renewable energy exist in these countries, but they need support to create changes in national energy policy. Growing awareness of the local potential for low-carbon power generation technologies, environmental consequences of fossil fuel and large hydropower use and the need to reduce greenhouse gas emissions provide an opportunity to shift energy policies in favour of renewable sources of energy. Growing awareness and providing concrete information on the status and potential of wind and solar energy resources in each country will help move China and South Africa off their carbon intensive trajectories and increase the proportion of non-large hydropower renewable sources in Brazil's energy mix.

This study documents crucial information to support renewable energies deployment in Brazil, China, and South Africa and provides policy-makers information for supporting renewable energy markets in these countries. Specifically, this report gathers concrete information of the existing solar and wind resources, renewable energy support policies, risk management and technologies associated with expanded renewable energy technology deployment.

The report analyses the solar and wind energy policies adopted by these countries to increase the deployment of both technologies. The results show that the existing policies have not reduced the growth of their combined annual greenhouse gas emissions over the past three decades.

BRAZIL

Solar and Wind Energy Resources
- Several solar and wind assessments available, most of them private, but some available to the public
- Estimated wind energy potential of 143.5 GW/year; 50% on north-eastern coast
- Country well-suited for solar energy exploitation; daily solar irradiation of 4-7 kWh/m^2

Policies/Instruments
- Reserve Energy Auctions, as held in 2009, exclusive to wind
- Brazil's policies have been criticized for their poor effectiveness
- PROINFA is the key programme to boost RE deployment, however does not include PV
- No national government programme to increase SHW but local SHW mandates in place for new buildings

Developers and Financiers
- Majority of PV and SHW system developers located in southern and south-eastern regions
- Most PV system developers are electricity utilities and research institutes
- High-quality local wind turbine industry; traditionally dominated by one manufacturer, but several international players have entered Brazil's market[(1)]

CHINA

Solar and Wind Energy Resources
- High resolutions wind resources assessments, in particular for 10 GW wind power bases, have been carried out
- Lack of high resolution solar resource assessments
- Solar resource measuring stations are not sufficient, especially in western regions

Policies/Instruments
- Most policies and instruments in current portfolio for advancing renewable energies have been implemented
- Renewable Energy Law and National Strategic Plan in place
- Fiscal tools: Feed-in tariff, R&D and investments subsidies, and favourable tax instruments

Developers and Financiers
- Almost all developers and financiers are one in the same; most wind and large PV system are large-scale state owned enterprises
- Growth in number of developers and financiers, including small and large enterprises from various fields, in the area of PV-roof systems

SOUTH AFRICA

Solar and Wind Energy Resources
- High resolution wind resource assessment in progress
- Lack of nation wide high-level solar resource assessments

Policies/Instruments
- 2003 White Paper identified target of 10,000 GWh of RE by 2013
- Renewable Energy Feed-In Tariff (REFIT) introduced in 2009, but no Power Purchase Agreements (PPAs) were signed by the end of 2010

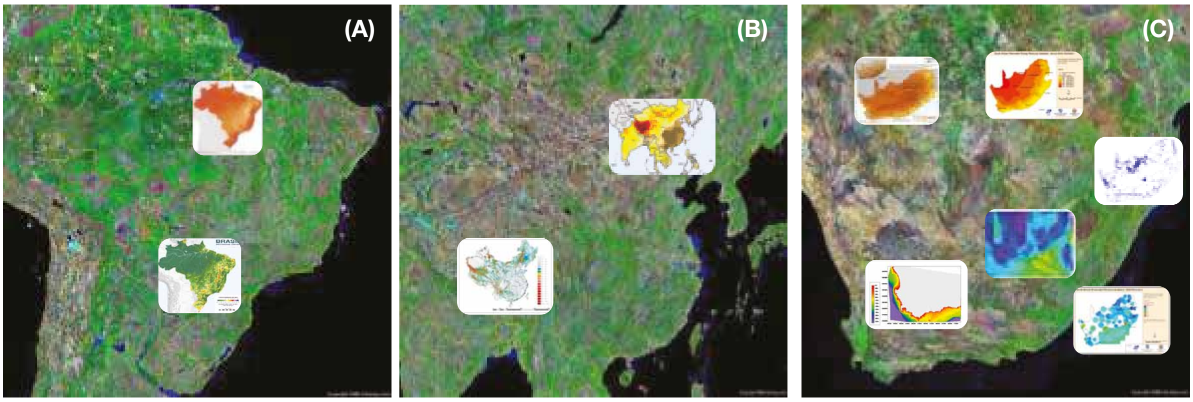
Developers and Financiers
- Large number of wind farms, large-scale PV and CSP projects in the pipeline proposed under the REFIT
- Many financial institutions willing to provide loans for RE projects

(1) http://swera.unep.net/ and http://www.cptec.inpe.br/sonda (2) Wobben Enercon including Vestas, Suzlon and IMPSA.

Solar and Wind Energy Resources

Section 1 (Wind and solar Energy Resource Assessment) collects, collates and describes the features of the existing and planned assessments of solar and wind energy resource potentials and the available datasets.

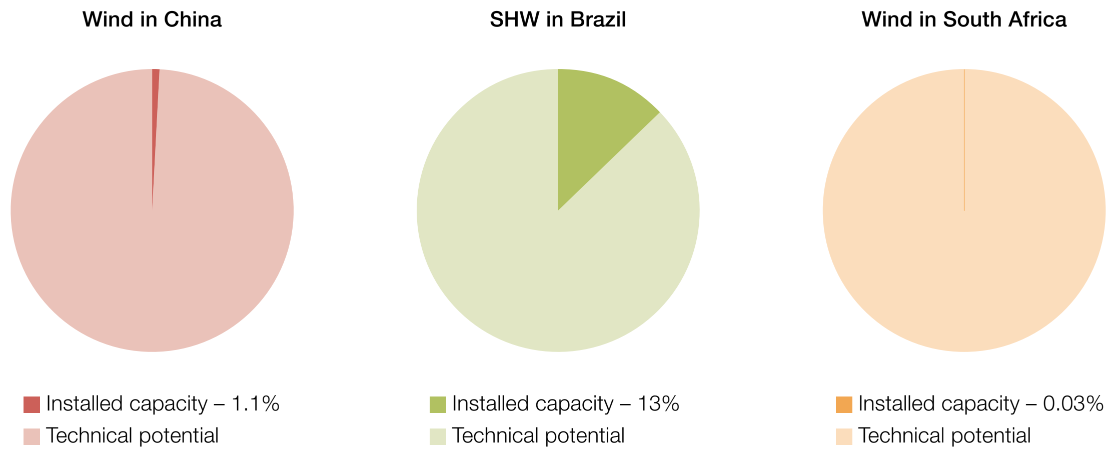
Figure 3 Solar and Wind Resource Information Available in (A) Brazil, (B) China and (C) South Africa



Knowledge of solar and wind energy resources is essential for the planning and operation of energy systems. This study reveals that even though the three countries have several energy resource assessments available, the use of these assessments has not been widely used. The reasons might be a lack of awareness of the existence of the resource assessments by the main stakeholders and a lack of centralized access to the assessment information. Depending on planned renewable energy projects, the lack of publicly available high-resolution and accurate energy resource information make the existing resource assessments unsuitable for specific applications, i.e. assessments of investment and operational cost, design of support instruments or plant feasibility studies. In 2010, South Africa lacked high-resolution solar and wind energy assessments, although an assessment is planned for wind energy (CSIR, SAWS, CSAG and Risoe, 2010). Solar and wind energy assessments are available for China, but have been validated only partially against measurement data and thus lack quantified uncertainty. Brazil has a wide range of solar and wind resource assessments available at the regional level but still lack high-quality assessments at the national level.

China, Brazil and South Africa's vast solar and wind resources are considered largely untapped. For example, a wind atlas published by the Electric Power Research Centre (CEPEL/ELETROBRÁS, 2001) estimates that in Brazil the potential for onshore wind energy capacity at 50 meters above ground level is 143 GW – double the country's current installed hydropower capacity – equivalent to a technical power generation potential of 273 TWh/year (Giulio Volpi, 2006), (Zakhidov, 2008).

Figure 4 Examples of Percentage of the Actual Solar and Wind Exploitation Compare to Technical Potential in China, Brazil, and South Africa



China exploits only 1.1% of its on-shore technical wind energy potential, South Africa exploits only 0.03% of its technical wind potential and Brazil exploits 14.8% of its solar thermal energy potential (0.4 out of 2.7 TWh) (for further details see Table I).

Table I Estimated Potential Energy Supply From Different Solar And Wind Energy Technologies In Brazil, China And South Africa

			Theoretical Potential (TWh)	Technical Potential	Installed Capacity (2009)	Percentage exploited (%)
Brazil	Solar	SHW		2.7 TWh	0.4 TWh	14.8%
		CSP	2,615,050[1]	n/a[2]	0	0%
		PV	6,897,050	n/a	6 MW	
	Wind	Offshore		n/a	0	0%
		Onshore		273 TWh 143 GW	602.3 MW	0.42%
China	Solar	SHW		7.5 TWth[3]	0.122TWh	1.6%
		CSP	170Ttce	2200 GW	0.1 MW	≈0%
		PV			300 MW	0.01%
	Wind	Offshore		400 GW[4]	102 MW	0.03%
		Onshore	3800 GW	142 TWh[5] 2,380 GW	26.9TWh 25,805 MW	1.08%
South Africa	Solar	SHW	70	47 TWh		
		CSP	2,361,300	1,000 TWh	0	0%
		PV (>1MW)	2,361,300	1,000 TWh 540.5 GW	20MW	0.004%
	Wind	Offshore			0	
		Onshore	184	80 TWh 30.6 GW	8 MW	0.03%

Source: (M.Edkins, Marquard y Winkler 2010), CRSES, Energy Research Institute at NRDC, INPE

1 According to a typical parabolic trough power station with respect to the solar energy irradiated per year on the total land surface required by the plant (Franz Trieb 2009). The area considered was chosen for DNI ≥2,100 kWh/m².y => 1,216,300km².
2 It is planned to estimate technical potential in the new edition of Brazilian Solar Atlas at the beginning of 2012.
3 If considering 50% of the roof areas could be used for SWH, the area will be 8900 million m².
4 The depth is no more than 50m.
5 Considering the average annual utilization hour of wind power is 2000, the potential of on- shore wind is 4760 TWh.

Summary of Solar and Wind Energy Resources in Each Country

BRAZIL

Solar and Wind Energy Potentials:
– Technical wind energy potential of 273 TWh/year
– Theoretical solar potential of 6,897,050 TWh[6] with an annual daily mean solar irradiation ranging from 4 to 7 kWh/m^2

There are several wind and solar energy resources assessments in Brazil. Most are privately owned, with few available to the public domain:

– **10 wind energy resource assessments:** Open range of resolution and quality	– 1 regional high resolution map – 1 statistical data collection, – 1 wind map/actual measurements comparison study – 6 low-resolution wind maps (2 validated measurement data) – 1 medium resolution map
– **4 solar energy resource assessments.**	– 3 solar maps (1 medium resolution, 1 low resolution, 1 isoline maps) and their corresponding datasets – 1 target and forecast assessment for RE electricity – Resource potentials are available in several publications; however, the methodologies applied vary; i.e. models based on ground station information or on satellite data.

– Lack of public national-level high-quality solar and wind energy assessments (2009), although one high-resolution assessment is planned for wind and one solar medium resolution (10 km) assessment is available.

– Several regional high-resolution wind energy assessments have been provided by investors and/or by state agencies, however, they were done using commercial tools or by foreign companies.

– Accuracy and resolution of publicly available maps and datasets are not appropriate for site selection, design and planning of large installations, such as CSP plants.

– SHW industry has been widely using solar data to assess the potential of systems.

CHINA

Solar and Wind Energy Potentials:
– Vast solar and wind resources exist however deployment is not near approaching the potential.
– Technical wind potential = 2,780 GW; Technical solar potential = 2,200 GW.

Wind energy resource assessments: Open range of resolution and quality	– High resolution maps at regional coverage – Statistical data collections of wind speed average – Comparison study of wind maps and field measurements – Low resolution wind maps at country level
Solar energy resource assessments: Low resolution	– 1 series of national level low-resolution maps and their corresponding datasets based on ground-stations – 1 series of national level low-resolution maps and their corresponding datasets based on satellite data and ground-stations – 1 national solar radiation database

Lack of high-resolution solar and wind energy assessments for the entire country (2009).

Lack of accuracy
Assessments of solar energy based on only few ground site measurements.

Accuracy and resolution
Publicly available solar maps and datasets are not appropriate for site selection, design and planning of larger installations, such as large PV and CSP plants.

Wind industry
Utilizing available wind energy resource assessment but these lack resolution. A high resolution map is being developed in order to identify potential sites for 50 GW wind farms.

6 Theoretical PV yield calculated as TWh/kWp for Brazil with DNI ≥2100 kWh/m^{2}y. Calculated under standard conditions to determine the Wp rating.

SOUTH AFRICA	
Solar and Wind Energy Potentials: Theoretical and technical potentials of solar in South Africa are vast, and greatly exceed the current energy demand of 220 TWh. The technical potential for wind is estimated at 80 TWh and for SWH at 47 per year.	
– **10 wind energy resource assessments** with wide range of resolution and quality	– 1 regional high resolution map – 1 statistical data collection – 1 wind map/actual measurements comparison study – 6 low resolution wind maps (1 with patches showing mean annual wind speed, 2 with validated measurement data) – 1 medium resolution map
– 2 reports containing information on energy resources	– RE-Independent Power Producers report – RE briefing paper
– **10 solar energy resource assessments**	– 7 low-resolution maps and their corresponding datasets (2 of the maps obtained by interpolation of measuring station data, 1 processing Meteonorm data) – 3 solar radiation databases
– Lack of high-resolution assessments of solar and wind energy (2009), although one high-resolution assessment is planned for wind.	
– Accuracy and resolution of publicly available maps and datasets are not appropriate for site selection, design and planning of larger installations, such as CSP plants.	
– SHW industry in ZA has been widely using solar data to assess the potential of the systems.	

National and Regional Policies

Section 2 (National and Regional Policies) collects and describes the national and regional policies for promoting solar and wind energy in each country, and documents the main technologies used in existing and planned solar and wind applications. Vast solar and wind resources are abundant in the three countries where deployment has not yet begun to approach potentials. As an example, China is becoming an important global player in the PV and wind sectors, however, fast economic growth and abundant conventional resources enable continued use of conventional fossil fuels (IEA PV Technology Roadmap, 2009). Without appropriate incentives and capacity to do otherwise, these countries are likely to follow carbon-intensive development paths. China is working now to meet domestic demand and ambitious renewable energy targets by installing substantial new clean energy-generating capacity. Brazil has one of the cleanest primary energy mixes (with 80% to 85% coming from large hydro) yet deforestation is a major source of GHG emissions. The country has put in place an array of policies and programs for the sustainable use of rainforests; however national policies supporting wind and solar deployment are still weak.

Policies and use of energy resource assessments: An analysis of the information collected shows that policies to promote solar and wind energy technology deployment in Brazil, China and South Africa are not based on integrated assessments (only partial assessments), and thus fail to reap the full economic, environmental and employment benefits of these technologies. Development of such integrated assessments – in the form of long-term policy roadmaps – is seen as a precondition for successful deployment of solar and wind energy technologies and to follow a low-carbon development path.

In the case of Brazil, governmental policies have concentrated more on wind energy than on solar and therefore more efforts have been made to develop high quality wind resource assessments. Even though wind energy is predominant; efforts have been made to expand knowledge of Brazil's solar resources in order to stimulate investments and technology development. The National Electricity Conservation Program, PROCEL, made use of solar resource assessments to ensure that solar heating was close to meeting the demand at peak hours. South Africa has an enormous potential for renewable energy projects and various studies are publicly available, however resource potentials are often not considered when discussing policy support options.

Since 2009, China's government has begun to promote eight wind power bases[7]. These wind park locations were identified taking into account partial resource assessments; they have rich wind resources on land and/or offshore. Furthermore wind power has been promoted in China since 2005 considering the technical and economic potential. China started to promote large-scale PV and CSP demonstration projects in 2010, however has not used high resolution solar resource assessments to support the development of these projects.

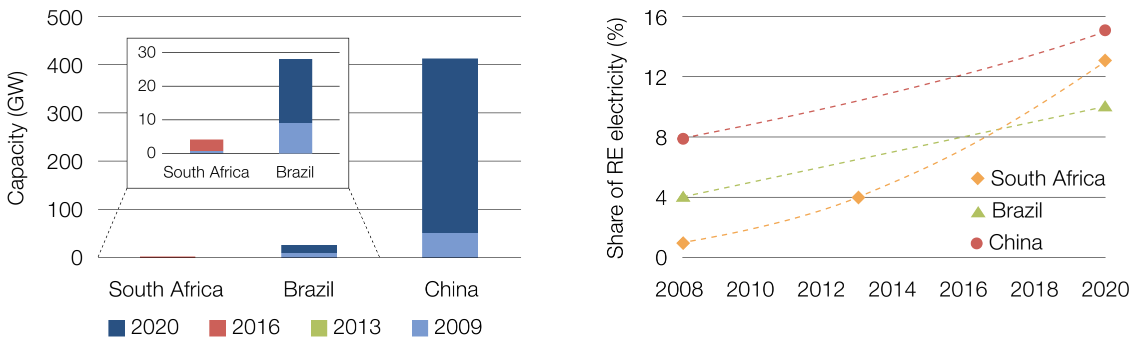
In South Africa policies have been mainly aimed at reducing CO_2 emissions taking into account current resource information available. The Renewable Energy Feed-In Tariffs (REFITs) have been determined using the principle of a fair return to the investors (they are currently being reviewed and may be substantially reduced.) When determining the Integrated Resource Plan 1 the least cost principle was employed, hence the uptake of RE was low.

Classification of wind and energy policies: Table II gathers information on the policy instruments for supporting the use of renewable energy sources for electricity in the three countries. Solar and wind energy instruments can be classified by (1) stimulating the RE electricity prices (or by establishing "price premiums"); or (2) establishing and promoting the installed capacity. A group of regulatory instruments may define the minimum amount of renewable energy to be produced or consumed (Centro Clima, 2010).

Targets for wind and solar energy: China has set ambitious targets (not officially announced yet) for wind, biomass and solar energy. The RE targets are foreseen to be 150 GW of wind power by 2020 and 20 GW of solar PV by 2020. The official targets in the 2007 RE Medium and Long Term Plan are a 15% share of renewables in the primary energy mix by 2020 with the following specific goals: 300 GW hydro, 30 GW wind, 30 GW biomass, 1.8 GW PV, and 300 million m^2 of SHW. To reach the envisaged government targets the current policies might not be consistent enough.

The South African government's target of achieving 4% of all power generated from renewable sources by 2013 has been criticised for not being ambitious enough. However, without adequate incentives this target is unlikely to be reached.

Figure 5 (5.A) Targets for New Renewable Energy Installed[8] (5.B) Targets for the Share of Electricity from Renewable in Brazil, China and South Africa



7 Wind Bases are very large wind parks, for example, the West Inner Mongolia Wind Bases will reach 20 GW wind capacity before 2020.
8 New renewables account for biomass, solar, small hydro and wind power combined.

Summary of Solar and Wind Energy Policies in Each Country

BRAZIL

Targets

– According to governmental energy plans: Slight increase in renewable energy share of primary energy and renewable electricity share.
– 3.3 GW added by 2006 from wind, biomass and small hydro – additional 3.3 GW by 2016.
– **Wind power** 2.7 GW by 2010 and 5,250 MW through new binding contracts by 2013.

Policies

The mechanisms adopted in Brazil to promote renewable energy technologies include auctions for specific sources and **Reserve Energy Auctions** (2009-2010), a **feed-in tariff** (2002), **guaranteed pricing**, **tradable certificates** and **third-party financing** for onshore wind energy, bio-energy and hydropower (2002-2012).

Deployment

– Combined new renewables such as biomass, small hydro and wind power account for less than 4% of the Brazil's electricity generation (85% of electricity generation is large hydro).
– Since the implementation of PROINFA (Alternative Energy Sources Incentive Program) in 2002, there has been more than a hundred-fold increase in the installed national wind energy capacity.

Lack of support for grid-connected PV

Brazil is well-suited for grid-connected PV due to the substantial solar resources available and match of solar irradiance peak with peak loads. Nevertheless, solar PV is not mentioned in PROINFA, the major national program for renewables.

Leading country for use of off-grid PV

In 2003, the federal government launched the electrification programme Luz para Todos (Light for All), which aims to supply full electricity access by 2010. As a result Brazil is one of the leading countries in the use of PV technologies for off-grid areas.

Several governmental incentive programs **promote large-scale use of solar water heating systems**.

Use of resource assessments in governmental policies

– National policies have targeted wind energy more than solar. Nevertheless, there are efforts to increase knowledge of Brazil's solar resources in order to stimulate investments and technology development.
– The National Electricity Conservation Program (PROCEL) made use of a solar resource assessment to ensure that solar heating goals could meet demand during peak hours.

CHINA

Targets

– China has set ambitious RE targets (not announced yet), to include a wind power target of 150 GW and a solar PV target of 20 GW by 2020.
– The official targets fixed in the 2007 RE Medium and Long term Plan were a 15% share of renewables in primary energy made up as follows: 300 GW hydro, 30 GW wind, 30 GW biomass, 1.8 GW solar PV and 300 million m^2 of SHW by 2020.

Policies

– Guaranteed prices determined by **bidding process**: Wind power concession (2003-2008) and large-scale PV has a guaranteed price through bidding since 2009.
– Reduced **VAT income** tax measures for wind technologies.
– **Feed-in-tariff for wind energy** since 2009, all other renewable energy technologies under the feed-in tariff as defined by the Renewable Energy Law (2005).The level of support is set by the provinces.
– **Capital grants** through the Brightness Rural Electrification Programme.

Deployment

– China is becoming an important global player in PV and wind, in terms of manufacturing capacity. However, PV production is vulnerable to changes in policies abroad as 95% of the produced technology is exported.
– Without sufficient incentives, China is likely to follow a carbon-intensive development path.

SOUTH AFRICA
Target Non-binding target of 10 TWh of renewable energy by 2013.
Policies – The White Paper on Renewable Energy (2003) aimed to remove barriers for the promotion of renewables and provide 10,000 GWh of RE by 2013. – **Feed-in Tariff** (REFIT) is the most important measure being implemented in 2009 but no Power Purchase Agreements were signed as of the end of 2010. While proposed by the National Energy Regulator of South Africa, the suggested feed-in-tariffs may not be high enough to stimulate significant investments (solar PV not included).
Use of resource assessment in governmental policies To date resources assessments have not been used in creating policy, except in the broader sense where it is recognised that ZA has significant solar resources and some wind and biomass potential. No high resolution wind atlas is available and none of the policies to date referred to any specific geographic area.

Wind and Solar Technologies

BRAZIL	
WIND	**Total installed capacity** – 602.3 MW (2009) and 931 MW by the end of 2010. The largest installed capacity in Latin America until 2010 consisting of nearly 50% of the total capacity. – However, it is less than 3% of the potential capacity estimated for Brazil, 143.5GW. – Total of 17 installed wind farms (2009), ranging from 0.3 MW to 50 MW. **Generating costs** Wind energy is already competitive with conventional sources (average of $0.08 /kWh); however, since the best locations are being used first, wind generating costs may rise again when the remaining locations are used. **Domestic production capacity** High-quality industrial capacity to produce wind turbines from 250 W up to 2.3 MW for domestic market and export (about 50% of annual production).
SOLAR	**Main solar energy technologies deployed** – More than 2.2 million square meters of solar water heaters installed for domestic use and small PV systems for off-grid applications. – Leading country in the use of PV for rural electrification. – Domestic production capacity of solar water heating industry is well developed. **Concentrating solar power (CSP)** No CSP plants or large PV systems are currently installed in the country.

CHINA	
WIND	**Installed capacity** – China is the world's largest market, with 13.8 GW added in 2009, more than one-third of the global market. – Wind capacity was doubled in 2009 in pursuit of an ambitious target of installing 30 GW of wind by 2020. **Domestic industry capacity** – Large-scale wind market is taking shape rapidly and the domestic industry is booming. – China remains the largest market for small wind turbines (2009).

SOLAR

Installed capacity

– Total capacity of 305 MW in 2009 (1/3 provided by independent producers' off-national grid).
– Major imbalance between PV production and domestic market. However, rapid expansion planned, setting up ambitious mid-term targets for domestic market, 1,800 MW installed capacity by 2020.

Domestic industry capacity

– PV industry has been growing rapidly; China is the world's leading ¬manufacturer of solar photovoltaic panels, with more than 40% share of global PV cell production in 2009 and about 50% in 2010.
– 95% of production is exported.
– Most raw materials and equipment are imported.

Solar Water Heaters

China dominates the world market with 70 % global installed capacity.

CSP

In early 2010, a deal was signed for at least 2 GW to be constructed in China by 2020, with installation of the first 92 MW to begin in 2010.

SOUTH AFRICA

WIND

Total installed capacity

Two operational farms:
– Klipheuwel 3.2 MW
– Darling wind farm 5.2 MW
Wind industry will boom with a viable feed-in-tariff.

SOLAR

Domestic production capacity

While the potential for solar is quite significant, the uptake of technologies has remained limited due to the lack of incentives.
Main solar energy technologies being utilized are solar water heaters for domestic use (744.4MW_{th})and small PV systems for off-grid applications.

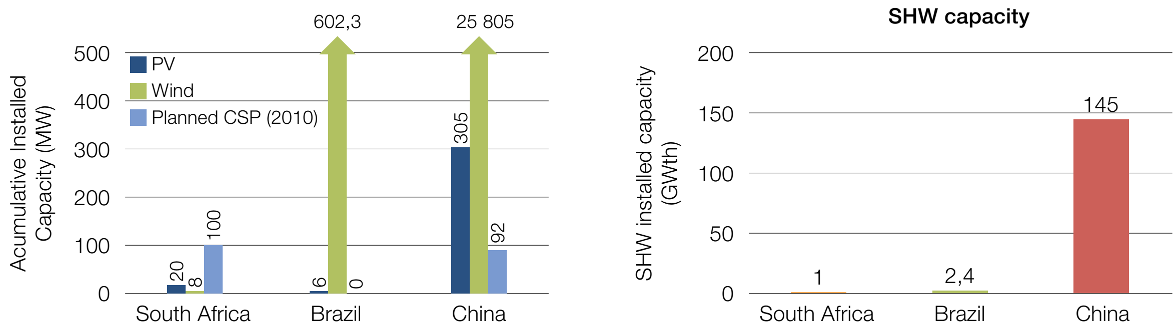
Large PV

No concentrating solar power plants or large PV systems are currently installed in the country.

CSP

The only concentrating solar power installation is a 25 kW Stirling dish system but it is out of operation. Eskom is planning a 100 MW solar tower near Upington, but finances have not been secured yet.

Figure 6 Accumulative Installed Capacity (2009) of Solar and Wind Technologies in Brazil, China and South Africa



Project Developers and Financiers

Section 3 (Project Developers and Financiers) collects information from the main project developers and project financiers in each country about their data requirements for risk management of solar and wind energy project development. The section analyses the most influential barriers to investments in renewable energy technologies in the three countries such as renewable energy capacity, research and development, installation and maintenance, financial risks and initial costs.

BRAZIL
– Ranked sixth worldwide in investment in renewable energy (2009); total of US$ 7,400 million.
– Wind project developers made use of the existing wind energy resource assessment that indicates the best economic conditions are in the Northeast and South regions.
– Wind and solar energy policies have encouraged investment by companies mainly in wind energy (no investments in large PV).
– High-quality domestic industrial capacity to produce wind turbines.
– Traditionally dominated by just one turbine manufacturer, Wobben Enercon, several other international players have entered the Brazilian market, including Vestas, Suzlon and IMPSA.
– There are no national manufacturers on the PV market in Brazil, dominated by small PV systems.
– Companies expect to see new renewable energy policy measures resulting from Brazil's National Action Plan on Climate Change and suggest policies focus on bringing down the cost of renewable power generation, e.g. through a special tariff, renewable energy credits, or reduced transmission costs for smaller renewable energy generators (REEEP, 2010).

Source: (Pew Research 2010), (REEEP 2010)

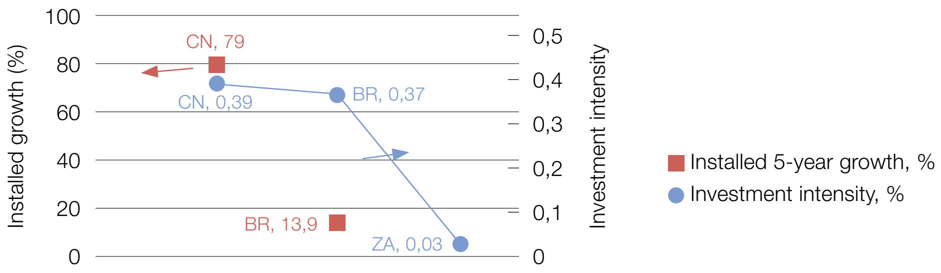
CHINA
– Ranked first worldwide overall in investment in renewable energy (2009), total of US$ 34,600 million.
– National policy on renewable energy has provided a clear signal to companies and has stimulated investment.
– Companies would like to see innovation in energy market structure and demand management, e.g. a renewable energy generation obligation, a renewable energy or emissions trading market, generation-based subsidies.
– The Clean Development Mechanism (CDM) has stimulated corporate investment, both directly (e.g. for project development) and indirectly (e.g. new business areas for service companies).

Source: (Pew Research 2010), (REEEP 2010)

SOUTH AFRICA	
WIND	There are a large number of wind farm developers and two main wind farm financiers.
SOLAR	Main developers and financiers are municipalities and provincial governments for solar water heater roll-out programs.
– Ranked seventeenth worldwide in overall investment in renewable energy (2009) total of 125 million US$.	
– The Renewable Energy Feed-in Tariff (2009) is changing investment patterns, however there is uncertainty about how it will be applied; technology-specific measures not favoured. By the end of 2010, large number of wind farms, large scale PV and CSP plants as proposed REFIT projects but no Power Purchase Agreements (PPA) were signed under the REFIT. Main stumbling blocks are the development of mutually acceptable PPAs and the selection criteria used to assess and rank project proposals.	
– Industry would like to see R&D support, simplification of planning consents, renewable energy targets and in-country support for CDM project development (REEEP, 2010).	
– Many financial institutions willing to provide loans for RE projects.	

China is emerging to the top spot for overall clean energy finance and investment. In 2009 China was ranked third among G-20 nations, with 0.39 percent, and Brazil forth, with 0.37 percent, in clean energy investment intensity (clean energy investment as a percentage of gross domestic product) (Figure 7). The five-year installed growth in installed capacity for Brazil and China are 79 % and 13.9 % respectively. The five-year growth in investment for Brazil and China is 148 percent each.

Figure 7 Investment Intensities in Renewable Energy Technologies (%) and Growth in the Installed Capacity (%) in Brazil (BR), China (CN) and South Africa (ZA)

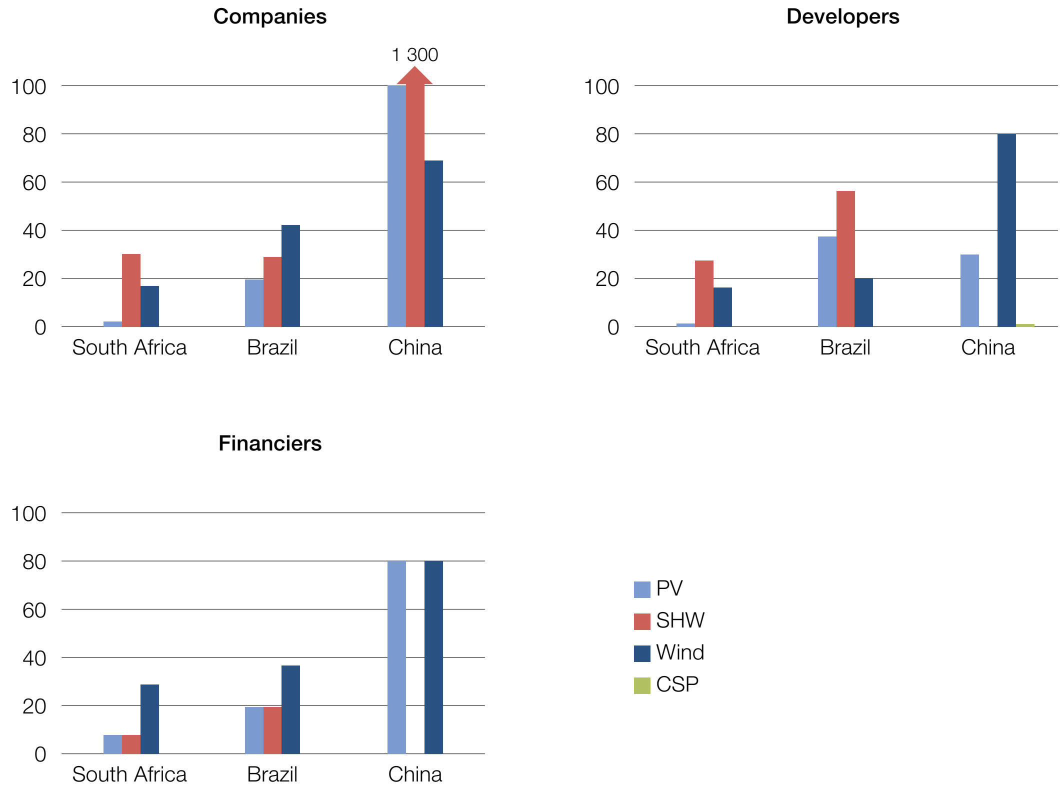


Source: (Pew Research 2010)

Each of the three countries have undertaken consultations with solar and wind energy companies, financiers and developers to study the most influential risk criteria from their point of view, such as the availability of resource information, standard approval or integration capacity of the existing grid.

Figure 8 shows the results after consultation of the number of existing companies, financiers and developers for solar and wind technologies in the three countries.

Figure 8 Companies, Project Developers and Financiers in Brazil, China and South Africa



BACKGROUND

High-quality assessments of solar and wind energy resources are indispensable for framing long-term, economically-sound policy frameworks for promoting solar and wind energy. However, these assessments are expensive and not profitable per se, because of the long causal chain between, on the one end, the assessment of the resource and, at the other end, the profitable investment opportunity which could attract private sector interest.

Public funding can help bridge this gap by (i) financing the development of high-resolution assessments of renewable energy, which the private sector clearly will not undertake, and (ii) supporting a UNEP-facilitated effort to take the results of those assessments through all the steps in the causal chain, to ensure that targeted, unbiased and timely information is made available to potential project developers and project financiers, and thereby help facilitate actual investment deals.

This study was commissioned by the United Nations Environment Programme in 2009 with the purpose of identifying best practices in promoting the use and development of renewable energy in Brazil, China, and South Africa (the "BASIC" countries excluding India). This report aims to map the extent to which solar and wind resource information in these three countries are being used and required; to identify the requirements for such information to support investments; and to evaluate the role of government policy in supporting renewable energy development.

Table II Selection of Major References Used in This Report

Study/Report	Solar/Wind Resources	Solar/Wind Policies	Investors / Developers	Solar/Wind Technologies
IEA PV Technology Roadmap	•	•		•
World Energy Resource	•	•		
Corp. Clean Energy Investment Trends – REEEP			•	
Pew Research.			•	
Centro Clima		•		
Econsense– Forum for Sustainable Development of German Business		•		
IEA. World Energy Outlook		•	•	•
Arcadia Market			•	
A sustainable electricity blueprint for Brazil	•	•		

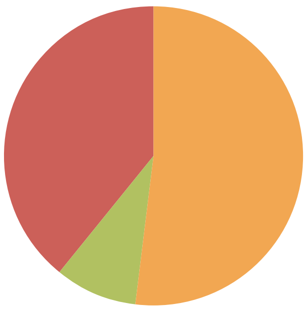
The primary data sources used for analysis were reports from the three project partners in 2009, complementary sources of information (see main sources in Table II) and additional interviews with governmental agencies and companies in 2009 and 2010 conducted by the partners in each of the three countries studied. The results were collated and complemented by UNEP and are classified in Annex I.

Introduction

The three countries examined in this report, Brazil, China and South Africa – three of the key "Big Emerging Markets" – reflect significant political, economic, demographic, and energy resource diversity. They include the country with the largest expanse of tropical forest (and third-largest emitter of total greenhouse gases in the world), the world's most populous nation and largest annual emitter of energy-related CO_2 (China overtook the United States in 2007), and Africa's largest greenhouse gas emitter. While their situations vary widely, these countries share common concerns that have motivated actions to reduce greenhouse gas emissions growth.

Brazil, China and South Africa increased their energy consumption at an annual rate between 8% and 200% from 1990-2009 and increased their primary energy consumption by 69%, 126% and 48%, respectively. The electricity and heat sectors in China and South Africa contribute most to emissions, 48% and 63% respectively in 2008. The bulk of Brazilian GHG emissions (85%) is from agriculture, land-use and forestry activities with only 11% coming from energy sector.

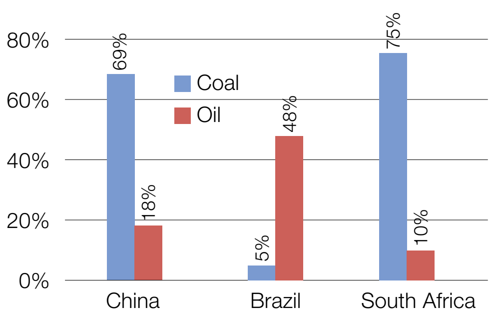
Figure 9 Contributions of Electricity and Heat Sectors to GHG Emissions



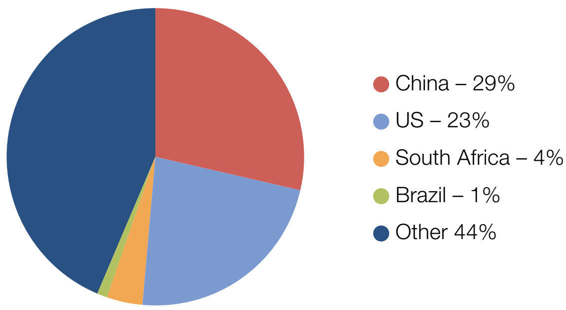
Renewable sources of energy could supply new generating capacity needed to keep pace with economic growth, as all three countries are well endowed with renewable sources of energy. However, to date, Brazil, China and South Africa have relied primarily on coal and large hydropower generation for power. The three countries exploit an insignificant share of their 'total realisable mid-term potentials' for solar and wind energy (IEA, 2009). For example, Brazil exploits 14.8 percent of its solar thermal energy potential (0.4 out of 2.7 TWh) and China exploits 1.08 percent of its on-shore wind energy potential (2.6 out of 142 TWh) (ERI, 2010). Moreover, potentials for use of off-shore wind energy, photovoltaic (PV) solar and Concentrating Solar Power (CSP) systems remain virtually unexploited.

Figure 10 Total Energy Consumption (2008)

Coal and oil in primary energy consumption



Coal consumption (% of billion short tons year)



WIND AND SOLAR ENERGY RESOURCE ASSESSMENT

The research, interviews and consultations conducted in this study reveal that there are already several wind and solar resource assessments available in each of the three countries although in general there is a lack of publicly available high-resolution assessments (2009).

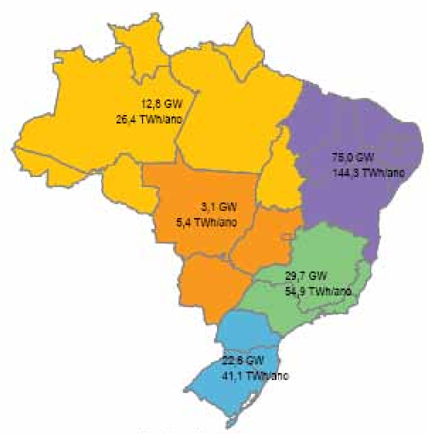
In 2010, South Africa lacked high-resolution solar and wind energy assessments, although an assessment is planned for wind energy (CSIR, SAWS, CSAG and Risoe, 2010). Assessments of solar and wind energy exist in China, but have been validated only partially against measurement data and thus lack accuracy. Brazil has a wide range of solar and wind resource assessments available (Martins, 2011) but still lack high-quality assessments at the national level.

Wind and Solar Resources Assessment in Brazil

Several studies have been developed to evaluate wind energy resources in Brazil. The national and regional wind atlases have done through support from a Brazilian government initiative to generate a reliable database necessary for planning and boosting wind energy exploitation. These publications have identified areas as possible locations for using wind energy. The best wind resources in terms of wind speed and capacity factor are in the Northeast, Southeast and Southern Regions (CEPEL/ELETROBRÁS. 2001).

A wind atlas published by the Electric Power Research Centre (CEPEL/ELETROBRÁS, 2001) shows that the potential for onshore wind energy capacity in Brazil is 143 GW (at 50 meters high) – double the country's current installed hydropower capacity (Giulio Volpi, 2006), (Zakhidov, 2008). New wind maps, which are being prepared by the government based on measurements at 80-100 meters, are expected to demonstrate a considerably higher capacity.

Figure 11 Wind Energy Potential in Brazil (143,4 GW in Total, 273 TWh/year)



Source:EPE (2007) http://www.aneel.gov.br/arquivos/PDF/atlas_par2_cap5.pdf

Solar energy has not been given as much attention in Brazil's government policies as wind energy has. Even so, there are efforts to expand knowledge of Brazil's solar resources in order to stimulate investments and technology development in this area. The resource potentials are available in several publications; SWERA Project Report, Atlas Solarimétrico do Brasil – Banco de Dados Terrestre, and Atlas de Irradiação Solar do Brasil. However, the methodologies used in the atlases vary; either using models based on ground station information on satellite data (see Table X).

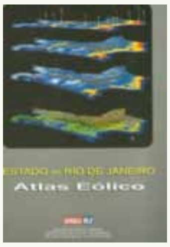
Interactive Solar and Wind Resource Map in Brazil

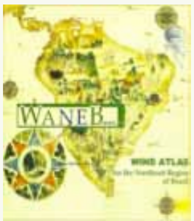
The most important wind and solar resource assessments for Brazil are represented in the following interactive map.

Figure 12 Interactive Solar and Wind Resource Map in Brazil

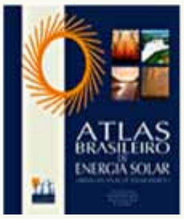
By clicking on an image, the solar/wind resource map and its main characteristics will be shown.

Table III Available Solar/Wind Resource Reports and Database in Brazil

	**Title: Solar and Wind Energy Resource Assessment in Brazil – SWERA Project Report.**	
	Authors/Sponsors	INPE,CEPEL/UNEP,GEF
	Year	2008
	Title: Brazilian Atlas for Wind Energy	
	Authors/Sponsors	CRESESB/MME– ELETROBRAS – CEPEL – CRESESB/
	Year	2001
	**Title: Wind Energy Overview for Brazil**	
	Authors/Sponsors	ANEEL/ANEEL
	Year	2003
	**Title: Wind Energy Atlas for the Rio Grande do Sul**	
	Authors/Sponsors	State Government of Rio Grande do Sul/State Company for Electricity
	Year	2003
	**Title: Wind Energy Atlas for the Rio de Janeiro**	
	Authors/Sponsors	SEINPE/SEINPE-ELETROBOLT
	Year	2003
	**Title: Wind Energy Atlas for the Alagoas**	
	Authors/Sponsors	ELETROBRAS, Technology Institute for Development and University of Alagoas
	Year	2009
	Title:Wind Energy Atlas for the São Paulo	
	Authors/Sponsors	Metropolitan Company for Water and Energy
	Year	2008
	**Title: Wind Map for the Paraná**	
	Authors/Sponsors	COPEL – Companhia Paranaense de Energia
	Year	1st edition in 1999, updated in 2009
	Title: Wind Energy Atlas for the Maranhão	
	Authors/Sponsors	State Government of Maranhão and University of Maranhão.
	Year	Planning



Title: Wind Energy Atlas for the Brazilian Northeast Region	
Authors/Sponsors	ANEEL/ANEEL
Year	1998



Title: Brazilian Atlas for Solar Energy	
Authors/Sponsors	INPE/UNEP/GEF
Year	2006

Title: Solar Radiation Atlas of Brazil	
Authors/Sponsors	INMET/INMET
Year	1998

Title: Brazilian Solarimetric Atlas Ground Database	
Authors/Sponsors	CRESESB/MME/ELETROBRÁS/CEPEL/CRESESB
Year	2000

Title: Brazilian Atlas of Electricity – 3rd edition	
Authors/Sponsors	Brazilian Agency for Electric Energy (ANEEL)
Year	2005

See Annex I for further details

Table IV Characteristics of the Available Solar Energy Resource Assessments in Brazil

Solar Assessments	Map/database	Validation	Resolution	Resolution
Brazilian Atlas for Solar Energy	maps	√	medium	10 km
Solar Radiation Atlas of Brazil	maps	√	low	50 km
Brazilian Solarimetric Atlas Ground Database	Isolines Charts and Maps	n/a		n/a
Brazilian Atlas of Electricity – 2nd edition	targets/forecast	n/a		n/a
SWERA Project Report in Brazil	Map/database	√	medium	10 km

Table V Available Wind Energy Resource Assessments in Brazil

Wind Assessments	Coverage	Validation	Resolution	Resolution
Brazilian Atlas for Wind Energy	Brazil	√ (1)	medium	1km x 1km
Wind Energy Overview for the Brazil	Brazil	√ (1)	medium	1km x 1km
Wind Energy Atlas for the Rio Grande do Sul	State of Rio Grande do Sul	√ (2)	medium	1km x 1km
Wind Energy Atlas for the Rio de Janeiro	State of Rio de Janeiro	√ (3)	high	200m x 200m
Wind Energy Atlas for the Alagoas	State of Alagoas	In progress	high	90m x 90m
Wind Energy Atlas for the São Paulo	State of São Paulo	√ (4)	high	200m x 200m
Wind Map for the Paraná	Paraná State	√ (5)	high	100m x 100m
Wind Energy Atlas for the Maranhão	State of Maranhão	In progress	n/a	n/a
Wind Energy Atlas for the Brazilian Northeast Region	Northeast of Brazil	√ (6)	low	
SWERA Project Report	Brazil	√ (7)	low	10km x 10 km

(1) 45 ground sites with anenometers at 50m.
(2) 22 anemometric towers at 50m (measurements acquired along 2 years).
(3) 5 anemometric towers (3 in lakes region, 2 in the N along shore) at 40m and 61m. Data were acquired along 22 months.
(4) Seven wind towers between 50m to 100m.
(5) 34 wind farms (one at 100 m).
(6) Data from 13 wind energy tower and 2 conventional meteorological stations.
(7) Ground data at airports, at automatic weather stations and at SONDA network sites.

In summary:

BRAZIL

Solar and Wind Energy Potentials:

– Technical wind energy potential of 273 TWh/year

– Theoretical solar potential of 6,897,050 TWh[9] with an annual daily mean solar irradiation ranging from 4 to 7 kWh/m^2

There are several wind and solar energy resources assessments in Brazil. Most are privately owned, with few available to the public domain:

– **10 wind energy resource assessments:** Open range of resolution and quality	– 1 regional high resolution map – 1 statistical data collection, – 1 wind map/actual measurements comparison study – 6 low-resolution wind maps (2 validated measurement data) – 1 medium resolution map
– **4 solar energy resource assessments.**	– 3 solar maps (1 medium resolution, 1 low resolution, 1 isoline maps) and their corresponding datasets – 1 target and forecast assessment for RE electricity – Resource potentials are available in several publications; however, the methodologies applied vary; i.e. models based on ground station information or on satellite data.

– Lack of public national-level high-quality solar and wind energy assessments (2009), although one high-resolution assessment is planned for wind and one solar medium resolution (10 km) assessment is available.

– Several regional high-resolution wind energy assessments have been provided by investors and/or by state agencies, however, they were done using commercial tools or by foreign companies.

– Accuracy and resolution of publicly available maps and datasets are not appropriate for site selection, design and planning of large installations, such as CSP plants.

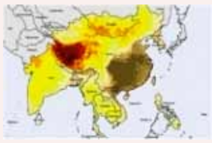
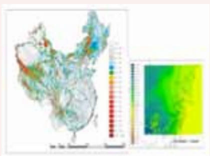
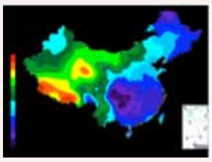
– SHW industry has been widely using solar data to assess the potential of systems.

9 Theoretical PV yield calculated as TWh/kWp for Brazil with DNI ≥2100 kWh/m^2y. Calculated under standard conditions to determine the Wp rating.

Wind and Solar Resources Assessment in China

Currently there are no publicly available high resolution solar and wind energy resource maps for China. Rough solar data can be derived from the global solar irradiation and direct irradiation maps developed by the Chinese National Meteorological Bureau (CNMB). Accurate GHI data are available from 122 on-site weather stations in China; but only 17 A-class weather stations measure both GHI and DNI data required for the design of PV and CSP systems. Further evaluation is required to obtain a reliable and accurate solar resource assessment in China.

Table VI Available Solar/Wind Resource Reports and Database in China

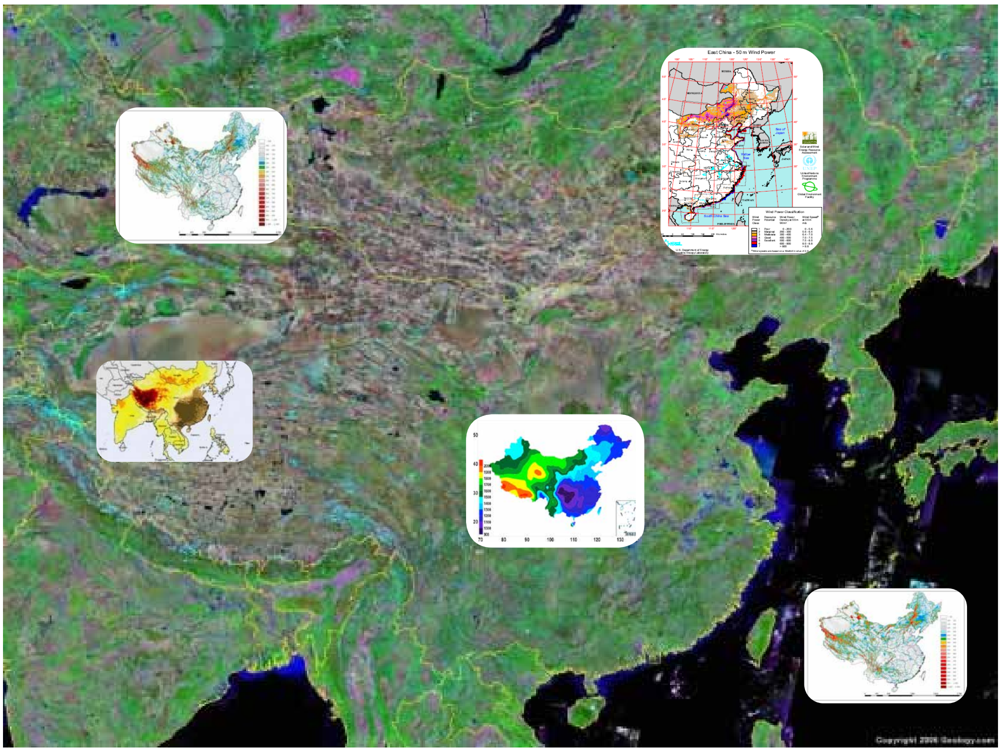
	**Title: National Wind Energy Resource Assessment**	
	Authors/Sponsors	National Development and Reform Commission (NDRC)
	Year	2004-2006
	**Title: China Wind Energy Resource Mapping Activity**	
	Authors/Sponsors	NREL/UNEP
	Year	2000-2006
	**Title: National Wind Energy Resource Detailed Assessment Activity**	
	Authors/Sponsors	Ministry of Finance
	Year	2007-2011
	**Title: Solar Resources Assessment for China**	
	Authors/Sponsors	Energy Research Institute, NDRC
	Year	1951-2008

See Annex I for further details

Interactive Solar and Wind Resource Map in China

The most important wind and solar resource assessments for China are represented in the following interactive map.

Figure 13 Interactive Solar and Wind Resource Map in China



By clicking on an image, the solar/wind resource map and its main characteristics will be shown.

Table VII Available Solar and Wind Energy Resource Assessments in China

Solar/Wind Assessments	Coverage	Validation	Resolution	Resolution	Accuracy
NDRC	National	×	Low	range classes of 50W/m^2	Low (1)
SWERA-NREL	Regional- Easter China	√	Medium	1 km^2 at 50 m height	Medium (2)
MOF	National-selected areas	√	Medium	1 km^2 at 10 m height	Medium (3)
CNMB	National	n/a	Low		Low (4)

(1) Due to lack of onsite measurements
(2) On-site tower measurements for 10 regions -170 meteo. stations
(3) Surface data from 400 wind measurement towers
(4) On-site measurement (122 stations for GHI, sunshine hrs. 752 stations)

In summary:

CHINA	
Solar and Wind Energy Potentials: – Vast solar and wind resources exist however deployment is not near approaching the potential. – Technical wind potential = 2,780 GW; Technical solar potential = 2,200 GW.	
Wind energy resource assessments: Open range of resolution and quality	– High resolution maps at regional coverage – Statistical data collections of wind speed average – Comparison study of wind maps and field measurements – Low resolution wind maps at country level
Solar energy resource assessments: Low resolution	– 1 series of national level low-resolution maps and their corresponding datasets based on ground-stations – 1 series of national level low-resolution maps and their corresponding datasets based on satellite data and ground-stations – 1 national solar radiation database
Lack of high-resolution solar and wind energy assessments for the entire country (2009).	
Lack of accuracy Assessments of solar energy based on only few ground site measurements.	
Accuracy and resolution Publicly available solar maps and datasets are not appropriate for site selection, design and planning of larger installations, such as large PV and CSP plants.	
Wind industry Utilizing available wind energy resource assessment but these lack resolution. A high resolution map is being developed in order to identify potential sites for 50 GW wind farms.	

Wind and Solar Resources Assessment in South Africa

There is a general agreement that solar energy resources in South Africa are outstanding, however no high resolution wind and solar maps are available in the public domain in 2010. Accuracy and resolution of public available maps and datasets are not appropriate for site selection, design and planning of larger installations, such as concentrating solar power plants or large process heat installations for industry.

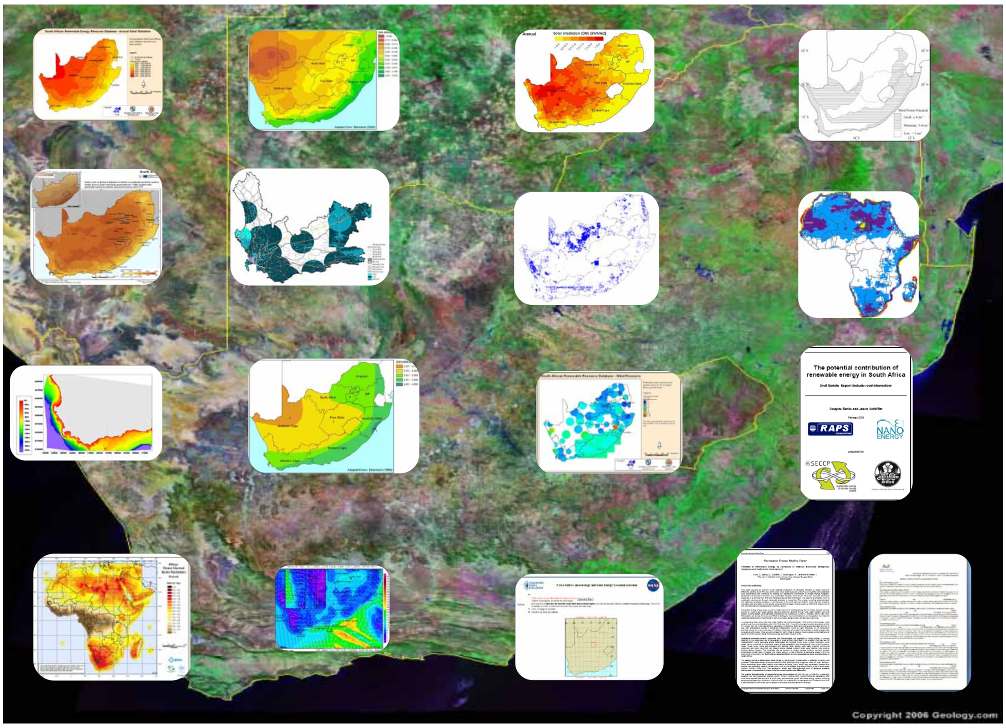
In two reports (Energy Research Centre, 2007); (Schaffle & Banks, 2006) large concentrating solar power (CSP) plants have been proposed for significant greenhouse gas emission reductions in South Africa. Both studies envisage an installed CSP capacity exceeding 20 GW by 2035. Currently, no CSP plants are in operation in the country, and none are under construction. It is expected that a sudden boom will be facilitated by the renewable energy feed-in tariff (REFIT), (NERSA, 2009). The REFIT for CSP, at ZAR 2.10 (which is equivalent to €0.18 at the exchange rate of 21 May 2009), should still be adequate to spur local implementation of the technology (Fluri, 2009).

There are 10 wind energy resource assessments with an wide range of resolution and quality: 1 regional high resolution map, 1 statistical data collection, 1 wind map/actual measurements comparison study, 6 low resolution wind maps (1 patched showing mean annual wind speed, 2 with validated measurement data), and 1 medium resolution map.

Interactive Solar and Wind Resource Map in South Africa

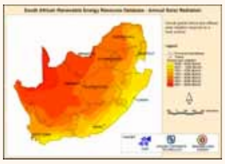
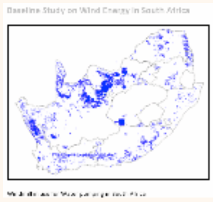
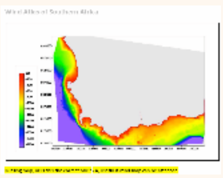
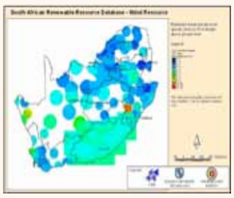
The most important wind and solar resource assessments for South Africa are represented in the following interactive map.

Figure 14 Interactive Solar and Wind Resource Maps in South Africa

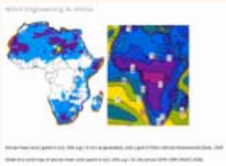


By clicking on an image, the solar/wind resource map and its main characteristics will be shown.

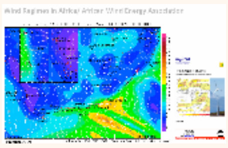
Table VIII Available Solar/Wind Resource Reports and Database in South Africa

	**Title: South African Renewable Energy Resource Database – Annual Solar Radiation**	
	Authors/Sponsors	ESKOM/CSIR/ESKOM/DME
	Year	1999
	**Title: A Proposed Renewable Energy Plan of Action for the Western Cape**	
	Authors/Sponsors	Restio Energy, Nano Energy/Department of Environmental Affairs and Development Planning
	Year	2007
	**Title: Baseline Study on Wind Energy in South Africa**	
	Authors/Sponsors	Department of Mineral and Energy/Department of Mineral and Energy
	Year	2003
	**Title: Review of Wind Energy Resource Studies in South Africa**	
	Authors/Sponsors	Department of Minerals and Energy/Department of Mineral and Energy
	Year	2003
	**Title: South African Renewable Resource database – Wind Resource**	
	Authors/Sponsors	Eskom/CSIR, Eskom, DME
	Year	1999
	Title: Bulk Renewable Energy Independent Power Producers in South Africa	
	Authors/Sponsors	Danish Cooperation for Environment and Development/DME, Danish Cooperation for Environment and Development
	Year	2001
	Title: Resource and Technology Assessment	
	Authors/Sponsors	RAPS Consulting
	Year	2006
	**Title: Renewable Energy Briefing Paper**	
	Authors/Sponsors	Holm, D., Banks, D., Schäffler, J., Worthington, R., and Afrane-Okese, Y./Unknown
	Year	2008
	**Title: The potential contribution of renewable energy in South Africa**	
	Authors/Sponsors	Sustainable Energy & Climate Change Project/DANIDA-Royal Danish Embassy
	Year	2006

Title: Wind Atlas of Southern Africa	
Authors/Sponsors	Diab, R./Department of Minerals and Energy
Year	Unknown



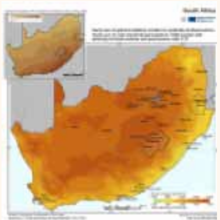
Title: Wind Engineering in Africa	
Authors/Sponsors	J. A. Wissea, K. Stigter Technical University Eindhoven
Year	2007



Title: Wind Regimes of Africa	
Authors/Sponsors	African Wind Energy Association/InWEnt Division
Year	2004

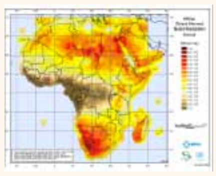
Title: A solar radiation data handbook for Southern Africa	
Authors/Sponsors	Eberhard, A., U. Cape Town/Energy Research National Programme – Foundation for Research Development
Year	1990

Title: Climate of South Africa – Sunshine and cloudiness	
Authors/Sponsors	South African Weather Service
Year	2005

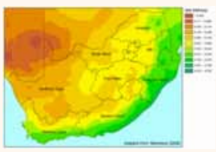


Title: PVGIS	
Authors/Sponsors	Joint Research Centre of the European Commission
Year	2001-2007

Title: NASA- Surface meteorology and Solar Energy	
Authors/Sponsors	NASA's Earth Science Enterprise Program
Year	2008 (release 6.0)



Title: SWERA – Solar resource data for Africa	
Authors/Sponsors	NREL/UNEP,GEF
Year	2006



Title: Meteonorm	
Authors/Sponsors	Meteotest, Switzerland
Year	2009

See Annex I for further details

Table IX Characteristics of Solar Energy Resource Assessments in South Africa

Solar Energy Assessment	Validation	Resolution	Resolution
A solar radiation data handbook for Southern Africa	×	low	n/a
Climate of South Africa – Sunshine and cloudiness	×	low	n/a
Munzhedzi et al.	very limited	low	1° lat. x 1° long.
PVGIS	n/a		n/a
JRC-European Commission	√	medium	2 km
NASA: Surface meteorology and Solar Energy	√ (1)	low	1° lat. x 1° long.
SWERA-NREL	√	very low	40 km x 40 km
Diabate et al.	√	low	n/a
South African Renewable Energy Resource Database – Annual Solar Radiation ESKOM	×	low	n/a
Meteonorm	×	Database	n/a

(1) Parameters based upon the solar and/or meteorology data were derived and validated based on recommendations from partners in the energy industry.

Table X Characteristics of the Wind Energy Resource Assessments in South Africa

Wind Assessments	Map/ Database	Coverage	Validation	Resolution	Resolution
A Proposed Renewable Energy Plan of Action for the Western Cape/Nano Energy	Map	Western Cape	√ (1)	n/a	– High (West coast) – Medium (rest of province)
Baseline Study on Wind Energy in South Africa /DME	Statistical data	South Africa	√ (2)	–	No wind map
Review of Wind Energy Resource Studies in South Africa/DME	Report on accuracy of existing maps	South Africa	√ (1)	–	No wind map
South African Renewable Resource database – Wind Resource/Eskom	Map	South Africa	×	Estimated mean annual wind speed at 10 m.	Low (Patchy)
Bulk Renewable Energy Independent Power Producers in South Africa		South Africa	–		–
Resource and Technology Assessment/RAPS consulting	Review of previous studies	KwaZulu Natal	–	n/a	n/a
Renewable Energy Briefing Paper/ Holm et al.	Review of previous studies	South Africa	–		n/a
The potential contribution of renewable energy in South Africa/ DANIDA	Review of previous studies/maps	South Africa	×		Low (Patchy)
Wind Atlas of Southern Africa/U, KwaZulu Natal	Map normalized at 10 m	South Africa	√ (1)	n/a	– Low for South Africa – Higher for Western Cape coast
Wind Engineering in Africa/ Technical University Eindhoven	Review of previous maps	Africa	×	– 50 km at 50 m – Mean wind speed at 10 m	Low
Wind Regimes of Africa/African Wind Energy Association		Africa and South Africa			Low

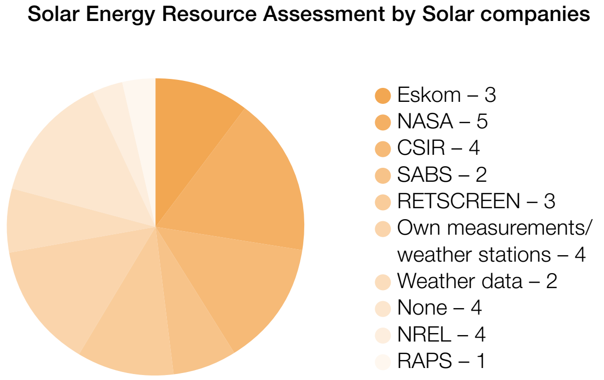
(1) Based on measured data
(2) Statistical data

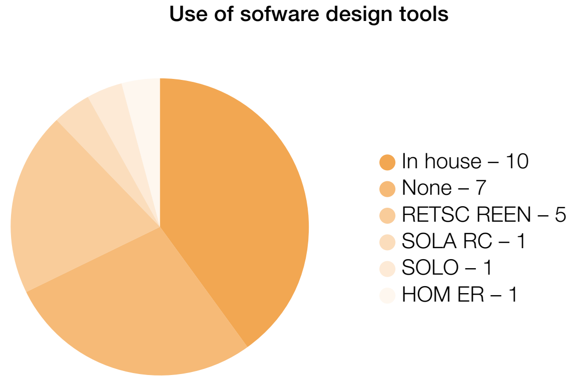
Almost 90% of the interviewed companies have been using solar energy resource assessments in their business and are highly satisfied with the results of the assessments used in terms of accuracy and resolution (mostly SHW industry).

Table XI Use of Solar Resource Assessments by Companies in South Africa

	Number of Companies contacted (interviewed)	Existing Energy Resource Assessments	Used Energy Resource Assessment	Software tools
Solar	42 SHW (19)	12	7	4
	21 PV (3)		9	4

Figure 15 Use of Solar Energy Resource Assessment by Solar Companies in South Africa





In summary:

SOUTH AFRICA	
Solar and Wind Energy Potentials: Theoretical and technical potentials of solar in South Africa are vast, and greatly exceed the current energy demand of 220 TWh. The technical potential for wind is estimated at 80 TWh and for SWH at 47 TWh.	
– **10 wind energy resource assessments** with wide range of resolution and quality	– 1 regional high resolution map – 1 statistical data collection, – 1 wind map/actual measurements comparison study – 6 low resolution wind maps (1 with patches showing mean annual wind speed, 2 with validated measurement data) – 1 medium resolution map
– 2 reports containing information on energy resources	– RE-Independent Power Producers report – RE briefing paper
– **10 solar energy resource assessments**	– 7 low-resolution maps and their corresponding datasets (2 of the maps obtained by interpolation of measuring station data, 1 processing Meteonorm data) – 3 solar radiation databases
– Lack of high-resolution assessments of solar and wind energy (2009), although one high-resolution assessment is planned for wind.	
– Accuracy and resolution of publicly available maps and datasets are not appropriate for site selection, design and planning of larger installations, such as CSP plants.	
– SHW industry in ZA has been widely using solar data to assess the potential of the systems.	

REVIEW OF NATIONAL POLICIES TO PROMOTE SOLAR AND WIND ENERGY

This section describes national and regional policies for promoting solar and wind energy in each country and documents the main technologies used in existing and planned solar and wind applications. Vast solar and wind resources exist in the three countries where deployment has not yet begun to approach its potential.

As an example, China is becoming an important global player in the PV and wind sectors, however, fast economic growth, and abundant conventional resources enable continued use of conventional fossil fuels (IEA PV Technology Roadmap, 2009). Without appropriate incentives and capacity to do otherwise, these countries are likely to follow carbon-intensive development paths. China is working now to meet domestic demand and ambitious renewable energy targets by installing substantial new clean energy-generating capacity. Brazil, has one of the cleanest primary energy mixes (with 80% to 85% is coming from large hydro) yet deforestation is the major source of GHG emissions. The country has put in place an array of policies and programs for the sustainable use of rainforests; however national policies supporting wind and solar deployment are still weak.

Policies and use of energy resource assessments: An analysis of the information collected illustrates that policies to promote solar and wind energy technology use in Brazil, China and South Africa are not based on integrated assessments, and thus fail to reap the full economic, environmental and employment benefits of these technologies. Development of such integrated assessments – in the form of long-term policy roadmaps – is seen as a precondition for achieving deployment of solar and wind energy technologies and to follow a low-carbon development path.

In the case of Brazil, governmental policies have concentrated more on wind energy than on solar and therefore more efforts have been made to develop high quality wind resource assessments. Even though wind energy is predominant; efforts have been made to expand knowledge of Brazil's solar resources in order to stimulate investments and technology development. The National Electricity Conservation Program, PROCEL, made use of solar resource assessments to ensure that solar heating was close to meeting the demand at peak hours. South Africa has an enormous potential for renewable energy projects and various studies are publicly available, however resource potentials are often not considered when discussing the policy support options.

Classification of wind and energy policies: Table XII outlines policy instruments for the promotion of renewable energy sources for electricity in the three countries. Solar and wind energy instruments can be classified by (1) stimulating the RE electricity prices (or by establishing "price premiums"); or (2) establishing and promoting the installed capacity. Regulatory instruments may define the minimum amount of renewable energy to be produced or consumed (Centro Clima, 2010).

Table XII Classification of Solar and Wind Policy Instruments in Brazil, China and South Africa

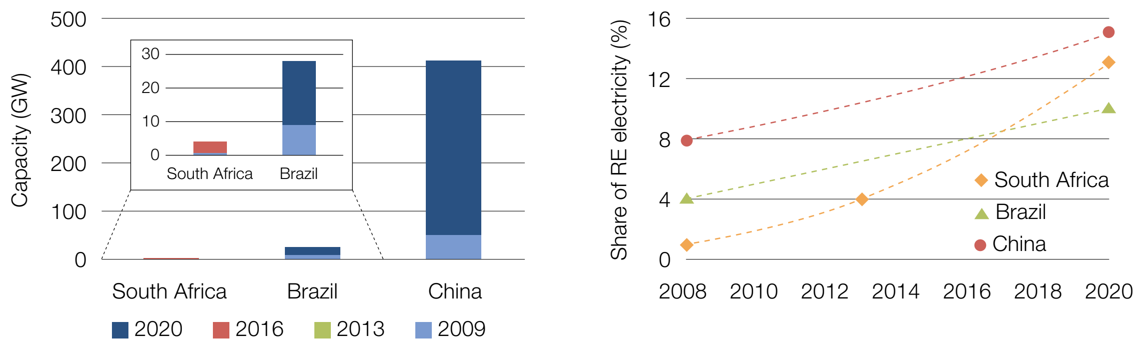
System		Price	Quantity
Regulated	Focused on Investment	**Financial Subsidy/Capital subsidies, grants or rebates** – BR: Biomass, mini-hydro, off-grid PV (Eletrobrás/ GTZ Technical Cooperation Project (2005); PROINFA-Promotion of RES market through incentives and subsidies (2002) – ZA: SWH up to 30% of capital cost (ESKOM), off-grid PV – CN	**Tender system/Public competitive biddings**
		Fiscal Incentives/Investment excise, or other tax credits – BR: Local and regional regulations; Solar Heaters in National Habitation Programs (2007); My home my life (2009); Light for all (2003) – CN: 50% VAT reduction for wind since Nov 2001 CN: Wind and Solar. Income tax free for first 3 yrs., 50% income tax reduction for next 3 yrs.	
	Based on Generation	**Feed-in tariffs** – ZA: REFIT (2009, not implemented) – CN: Since 2009 for wind – BR: PROINFA, 2002	**Tender system/Public competitive biddings** – CN: Wind (2003-2008) – CN: Solar PV (2009 to present) – BR: Wind (2009-2010) – ZA: Wind (delayed or abandoned))
		Fiscal Incentives/Energy production payments "tax credits" – ZA	**Quota System With Green Certificates (RPS)** – CN (2007)
Voluntary	Focused on Investment	**Shareholder Programs** – ZA: RE 2003 – BR: PROCEL – National Electricity Conservation Program (1985) – CN: WP 2009, REP 2009	**Voluntary agreements based on a defined quantity with green certificates** – BR, CN, ZA (non existing)
		Financing Programs – BR (not-known) – CN ($400 billion funds)	
	Based on Generation	**Green tariffs** – BR, CN (non existing) – ZA: Green Certificates in Cape Town	

Source: Centro Clima/PPE/COPPE/UFRJ, INPE, Fraunhofer ISI, Research and Costa (2006), ERI, INPE, CRSES

Targets for wind and solar energy: China has set ambitious targets (not officially announced yet) for wind, biomass and solar energy. The RE targets were foreseen as 150 GW of wind power by 2020 and 20 GW of solar PV by 2020. The official targets in the 2007 RE Medium and Long Term Plan are 15% share of renewable in primary energy by 2020 with the following specific goals: 300 GW hydro, 30 GW wind, 30 GW biomass, 1.8 GW PV, and 300 million m^2 of SHW. To reach the envisaged government targets the current policies might not be consistent enough.

The South African government's target of achieving 4% of all power generated from renewable sources by 2013 has been criticised for not being ambitious enough. However, without adequate incentives this target is unlikely to be reached.

Figure 16 (16.A) Targets for Renewable Energy Installed (16.B) Targets for the Share of Electricity from Renewable in Brazil, China and South Africa



The main characteristics of the existing wind and solar energy promotion policy instruments are summarized and compared in the table below.

Table XIII Wind and Solar Energy Promotion Policy Instruments in Brazil

Policy Instrument	Regulated vs. Voluntary	Investment vs. Generation	Goal		Actual (2009)	Forecast
PROINFA-Promotion of RES market through incentives and subsidies (2002)	Voluntary: Strategic at short term	Investment	3.3GW total to National Grid:		2.074 GW	3.3 GW
			Wind	1.1 GW	602.3 MW	1423 MW
			Small-scale hydro	1.1GW	1135 MW	1191 MW
			Bio-mass	1.1 GW	514 MW	685 MW
Emergency Program of Wind Energy – PROEÓLICA (2001)	Voluntary	Investment: Incentive for wind turbines importation Generation: Federal government guarantees purchase of wind- electricity by state utility for 15 yrs	Addition of 1050 MW of wind capacity to the national grid by December 2003.			
Light for all (2003)	Voluntary: Strategic at short term	Investment	100% of population has access to electricity by 2008 Program behind schedule, decree extended to 2010			
National Electricity Conservation Program (1985)	Voluntary: Short-term measure	Investment: Credit and financing for rational use of energy and increase energy efficiency	Support energy efficiency among energy utilities[1] and final users.		On-going	Up to 18% reduction of the electricity demand in 2018

Policy Instrument	Regulated vs. Voluntary	Investment vs. Generation	Goal	Actual (2009)	Forecast
Public Policy Programs and Incentives for Solar Heaters (2005)	– Mandatory for new buildings – Voluntary for existing buildings	Investment: Will be proposed after regulation by the Executive of Federal government.	n/a[2]	n/a[2]	n/a[2]
National Policy for Alternative Energy (2007)	Mandatory	Investment: – R&D government investments – Federal tax incentives – Funding support with long-term interest	n/a[2]	n/a[2]	n/a[2]
Solar Heaters in National Habitation Programs (2007)	Mandatory	n/a	n/a[2]	n/a[2]	n/a[2]
Solar Heaters in Buildings supported by PNH and PAC (2007)	Mandatory	Investment: Outlines requirements of SWH financed by the PNH and PAC National Programs	n/a[2]	n/a[2]	n/a[2]
Alternative Energy for Isolated Systems Program, Solar Energy for Water Heating Program and Distributed Generations Program (2007)	Mandatory	Investment: Provides requirements to promote distributed electricity generation and energy efficiency by using renewable energy.	n/a[2]	n/a[2]	n/a[2]
Brazilian Program for Solar Heaters – PROSOL (2008)	Mandatory	Investment: National Fund supported by 0,1% of Annual Gross Revenue of Electricity companies	n/a[2]	n/a[2]	n/a[2]
Eletrobrás/ GTZ Technical Cooperation Project (2005)	Mandatory	Investment: Support to power distribution utilities in the North and Northeast	25,000 electric connections	n/a[2]	n/a[2]
Renewable Sources of Energy (2009)	Mandatory	Investment: National Fund for Research and Development of Alternative Sources and Renewable Energy[3]	n/a[2]	n/a[2]	n/a[2]
REINFA – Incentive Program for Development and Exploitation of Alternative Sources of Energy (2009)	Mandatory	Investment: Tax incentives for R&D in renewable energy, storage and generation technology and devices with better efficiency.	n/a[2]	n/a[2]	n/a[2]

(1) Generation, transmission and distribution.
(2) Waiting for approval in Brazilian Congress.
(3) Royalties from oil; net operating revenues resulting from the operation of thermal power plants; federal resources, electricity tax.

Table XIV Wind and Solar Energy Promotion Policy Instruments in China

Policy Instrument	Regulated vs. Voluntary	Investment vs. Generation	Goal	Actual (2009)	Forecast
Middle and Long-term Renewable Energy Development Strategy (2005-2020) and **"11th-Five-Year" Renewable Energy Development Plan (2005-2010)**	Voluntary	Non-binding target	**Wind** – *M and L Strategy:* 5 GW (2010) 30 GW (2020) – *11th- Plan:* 10 GW (2010) 30 GW (2020)	– 6 GW by the end of 2007 – 12 GW in 2008 (exceed national target for 2010 of 10 GW)	20 GW (2010)
			Solar PV 300 MW in 2010 1.8 GW in 2020	100 MW in 2007 130 MW (estimated) in 2008	300 MW (2010)
			Solar water heating 150 million m^2 (2010) 300 million m^2 (2020)	108 million m^2 (2007)	150 million m^2 (2010)
Regulation of Renewable Power Pricing and Cost Sharing(2006)	Regulated	Generation: Subsidy on power price	**Wind** – *M and L Term Strategy:* 5 GW (2010) 30 GW (2020) – *11th- Plan:* 10 GW (2010) 30 GW (2020)	– 12 GW in 2008 (exceed 2010 target of 10 GW) – Strong turbine manufacturing industry as result of the stimulating market.	– Capacity could reach 20 GW (2010) – At least 60 GW or, 100 GW (2020)
			Solar PV 300 MW in 2010 1.8 GW in 2020	– Lack of power price policy. Four pilot projects(1) with power price subsidy by 2009 – Government planning bidding for selection of PV developers; the 1st bidding project was conducted in March 2009; power price is the most important factor.	

Policy Instrument	Regulated vs. Voluntary	Investment vs. Generation	Goal	Actual (2009)	Forecast
Special Fund for Localization of the Manufacturing of Wind Turbines (2008)	Regulated	Investment: Financial tool – Subsidy for Wind	Subsides for assembling and components manufactures (50% respectively). 600 RMB Yuan/kW subsidy per turbine (US$ 82/kW, based on the exchange rate in 2007) for the first 50 units. Requirements. 1. Wind turbine ≥1 MW 2. Chinese manufactures[(2)] 3. Developed by and/or belonging to Chinese enterprise	Several manufactures received subsidies	– Estimated that more manufactures will benefit from subsidy. – The fund will stimulate improvement of design and manufacturing of new turbines.
Policy on VAT for Some Resource Comprehensive Utilization Projects and Other Products	Regulated	Investment: Financial tool – Tax	8.5% VAT for wind power projects (the general VAT rate is 17%)	– All wind power projects benefit from VAT policy[(3)] – By 2010, about 31 GW increase through the policy	The policy will continue and with higher positive impact
Special Fund for Renewable Energy Development (2006)	Regulated	Investment: Financial tool – subsidy	To Support, 1. R&D, standard and demonstration projects 2. RE projects in rural areas 3. Independent RE systems in remote areas and islands 4. Resources survey, assessment and database for RE 5. Manufacturing localization of RE facilities	Ministry of Finance arranged the Special Fund through many channels[(4)]	Expected that the fund will cover broad renewable fields[(5)]

(1) Two projects are the Solar-PV-Building in Shanghai and the Solar-PV-in desert areas in Inner Mongolia with power subsidy of 4 RMB Yuan/KWh. (about US$ 0.58/kWh, based on the exchange rate in 2009).
(2) Or Chinese companies (51% stakes)
(3) In particular, before 2006 there was no feed-in-tariff policy for wind power in China.
(4) In 2007, 300 million Chinese RMB Yuan (about US$ 41 million, based on exchange rate in 2007) for National Wind Energy Resource Detailed Assessment Program (from 2007-2011), with the expected output of at least 50GW detail wind power resources survey.
(5) Such as new renewable village power programs, and resources survey for solar energy, and solar pilot projects including solar-PV roof-systems etc.

Table XV Wind and Solar Energy Promotion Policy Instruments in South Africa

Policy Instrument	Regulated vs. Voluntary	Investment vs. Generation	Goal	Actual (2009)
White Paper on Renewable Energy(2003)	Non-binding target	Several financial and legal instruments are proposed but not yet implemented	– 10 TWh RE by 2013 – 4% of RE electricity by 2013	Not yet achieved
Renewable energy framework, DME (2003)	Strategic: Regulated	Generation: – The production tariff was determined evaluating the estimated capital cost and the levelised cost of electricity together with the NERSA tariff	– 10 TWh RE by 2013 – 4% of RE electricity by 2013	Not yet achieved
Renewable Energy Market Transformation Project, DME/DBSA (2009)	Voluntary: Technical assistance	Generation: – Financing mechanisms cover incremental cost renewable; Investment (SWH): – Grants strengthen capacity of the private sector	– 10 TWh RE by 2013 – 4% of RE electricity by 2013	Not yet achieved
Long-term mitigation scenarios (2007)	Voluntary: Policy Support	Data-based scenarios	– Outline different scenarios of mitigation; – Inform long-term national policy; – Provide solid basis for negotiations on a post-2012 climate regime.	Comprehensive report
City of Cape Town – Energy and Climate Change Strategy(2006)	Voluntary: Policy Support		– Reduce climate change through the promotion of sustainable energy use; – Identify most vulnerable communities to minimise impacts of climate change.	– Setting of energy targets and monitoring/ enforcing them.
Solar Water Heater by-law – City of Cape Town (in planning)	Compulsory	– The bylaw will be implemented through building plan approvals. – Sanctions with fines.	– 10% of homes equipped with SWH by 2010 – 10% of City-owned housing with SWH by 2010	n/a
Green Certificates – City of Cape Town (2010)	Voluntary	Generation: Green certificates (non-tradable)	Sell generated electricity by Darling Wind Farm to Cape Town customers	– Electricity generation of 13.2 GWh per annum
REFIT – NERSA (2009)	Compulsory	Generation: Feed-in tariffs		Not advancing

Review of National Policies to Promote Solar and Wind Energy in Brazil

The mechanisms currently adopted in Brazil to promote the use of renewable energy sources are auctions for specific sources done in 2008, and Reserve Energy Auctions, also done in 2008 exclusively for biomass, and in 2009 exclusively for wind.

The main criticism of the government policies is that they have had little effect on promoting renewable energy sources for electricity generation. PROINFA was the key program for increasing the deployment of renewable energy for electricity generation. However, PV systems were not addressed in PROINFA or any other government energy sector program. Currently, there are no government programs specifically for increasing the penetration of solar heating technology in homes, public buildings or for industrial applications, however, there are local and regional regulations that make SHW in new buildings mandatory.

It has been claimed that in Brazil electricity from wind is already competitive with conventional sources. However wind power generating costs may increase when the best resource locations are used, then new incentives would be necessary to maintain wind's competitiveness and promote other renewables such as solar energy.

Table XVI Wind and Solar Energy Promotion Policy Instruments in Brazil

National Policy	Goal	Nature	Instruments	Resources	Sector
Promotion of RES market-incentives and subsidies (2002)	Promote use of RES (wind, biomass and small hydro).	Strategic: – Short-term measures	– Funding with long-term interest by National Economic and Social Development Bank – 20 year contracts with guaranteed return of 70% of the energy and full protection to risk in energy market – investments in R&T	Biomass, Small Hydro and Wind	Electricity
Emergency Wind Energy Program –PROEÓLICA (2001)	Addition of 1,050 MW wind capacity to the national grid by Dec. 2003.	Emergency	The federal government guarantees a purchase of wind-generated electricity by state utility Eletrobras for at least 15 year.(1)	Wind	Electricity
Light for all (2003)(2)	Deliver electricity in remote regions not grid-connected.	Strategic: Short term measure to improve access to electricity and social development.	Total budget: US$ 7billion Government program involving local, state and federal institutions together with energy companies. Regulates and establishes the "Energy Development Account" to financially support the program.	Open to all energy resources for remote areas; strong presence solar and wind.	Electricity
National Electricity Conservation Program (1985)(3)	Provides for National Electricity Conservation Program (PROCEL) in order to arrange and manage actions and procedures aiming at the conservation of energy	Strategic: Short term measure to improve energy efficiency and promote rational use of energy.	– Decree published in 1994, provides for the official financial agents, the inclusion among the priority lines of credit and financing of projects for the conservation and rational use of energy and increase energy efficiency, including research projects and technological development. – Decree published 1993, provides the creation of the Energy Efficiency Label – National Award for Conservation and Rational Use of Energy: recognition of contributions towards the conservation and rational use of energy. – Law published on 2001: investments in R&D in energy efficiency under responsibility of energy companies.	Solar (it includes solar heating to substitute hot water electric heaters).	Electricity
Public Policy Programs and Incentives for Solar Heaters (2005)	– Obligation for SWH in housing. – Authorizes the Executive Power to create Public Policy Programs and Incentives for deployment and use of SHW.	Mandatory for new buildings projects. Voluntary for other buildings.	Will be proposed after regulation by the Executive of the Federal government.	Solar	Water Heating

National Policy	Goal	Nature	Instruments	Resources	Sector
National Policy for Alternative Energy (2007)	Provides the National Policy for Alternative Energy	Mandatory	– Federal Tax Incentives, – Funding support with long-term interest, – Government Investments in R&T.	Biomass, Hydro, Solar and Wind	Water Heating, Liquid Fuels, Transportation, Electricity
Solar Heaters in National Habitation Programs (2007)	To provide requirements for using SWH in buildings	Mandatory	n/a (It has not been yet regulated by Brazilian Congress).	Solar	Water Heating
Solar Heaters in Buildings supported by PNH and PAC (2007)	To provide requirements for solar heaters in public housing and non-residential buildings	Mandatory	Mandatory SWH financed by: – National Accelerated Growth Program – National Habitation Plan	Solar	Water Heating
Alternative Energy for Isolated Systems Program, Solar Energy for Water Heating Program, and Distributed Generations Program (2007)	To promote distributed generation[6] through use of renewable energy resources	Mandatory	– Alternative Energy for Isolated Systems Program (FAJS); – Solar Energy for Water Heating Program (PAES); – Distributed Generations Program (PGD)	Solar	Water Heating
Brazilian Program for Solar Heaters – PROSOL (2008)[4]	To promote the Brazilian Program for Solar Heaters – PROSOL	Mandatory	National Fund supported by 0,1% of Annual Gross Revenue of Electricity companies	Solar	Water Heating
Eletrobrás/ GTZ Technical Cooperation Project (2005)	To help power distribution utilities in the North and Northeast to achieve the goals of the Program of Universalized Electric Power through the use of RE	Mandatory	DEP – Management Department of Eletrobrás for Universalization Program	Solar, wind and biomass	Rural electrification/ photovoltaic

National Policy	Goal	Nature	Instruments	Resources	Sector
Renewable Sources of Energy (2009)	– To provide incentives for renewable energy use and alternative fuels, – To establish the National Fund for Research and Development of Alternative Sources and Renewable Energy.	Mandatory	– National Fund for Research and Development of Alternative Sources and Renewable Energy(5)	Solar , Wind, Biomass and Hydrogen	Energy production
REINFA – Incentive Program for Development and Exploitation of Alternative Sources of Energy (2009)	– To provide incentives for development of alternative sources of energy – To set out measures to stimulate the production and consumption of clean energy.	Mandatory	– Tax incentives for R&D in renewable energy, storage and generation technology and devices with better efficiency	Renewable sources of energy	Energy production

(1) In July 2001, in the midst of the electricity crisis brought on by persistent drought, the Power Crisis Management Chamber established the PRÓEÓLICA emergency wind energy program. The rule of law does not promote a long-term establishment of a wind industry in Brazil, but has created an incentive for the importation of wind turbines.
(2) It does not directly address wind and solar energy but considers both viable in remote areas far from the electricity grid, http://www.eletrobras.gov.br/EM_Programas_Proinfa/default.asp
(3) http://www.eletrobras.com/pci/main.asp?TeamID={1C05658A-8C93-46EA-AC53-7ED9022085E2}
(4) http://www.camara.gov.br/sileg/MostrarIntegra.asp?CodTeor=5465
(5) Royalties from oil; net operating revenues resulting from the operation of thermo power plants; federal resources, electricity tax.
(6) Modifies the Law no. 10438 in order to increase the renewable energy share in the Brazilian Energy Matrix.
PNH – National Housing Policy, Growth Acceleration Programme – PAC

In summary:

BRAZIL
Targets – According to governmental energy plans: Slight increase in renewable energy share of primary energy and renewable electricity share. – 3.3 GW added by 2006 from wind, biomass and small hydro – additional 3.3 GW by 2016. – **Wind power** 2.7 GW by 2010 and 5,250 MW through new binding contracts by 2013
Policies The mechanisms adopted in Brazil to promote renewable energy technologies include auctions for specific sources and **Reserve Energy Auctions** (2009-2010), a **feed-in tariff** (2002), **guaranteed pricing**, **tradable certificates** and **third-party financing** for onshore wind energy, bio-energy and hydropower (2002-2012).
Deployment – Combined new renewables such as biomass, small hydro and wind power account for less than 4% of the Brazil's electricity generation (85% of electricity generation is large hydro). – Since the implementation of PROINFA (Alternative Energy Sources Incentive Program) in 2002, there has been more than a hundred-fold increase in the installed national wind energy capacity.
Lack of support for grid-connected PV Brazil is well-suited for grid-connected PV due to the substantial solar resources available and match of solar irradiance peak with peak loads. Nevertheless, solar PV is not mentioned in PROINFA, the major national program for renewables.
Leading country for use of off-grid PV In 2003, the federal government launched the electrification programme Luz para Todos (Light for All), which aims to supply full electricity access by 2010. As a result Brazil is one of the leading countries in the use of PV technologies for off-grid areas.
Several governmental incentive programs **promote large-scale use of solar water heating systems**.
Use of resource assessments in governmental policies – National policies have targeted wind energy more than solar. Nevertheless, there are efforts to increase knowledge of Brazil's solar resources in order to stimulate investments and technology development. – The National Electricity Conservation Program (PROCEL) made use of a solar resource assessment to ensure that solar heating goals could meet demand during peak hours.

Review of National Policies to Promote Solar and Wind Energy in China

China is becoming an important global player in the PV and wind sectors, however, fast economic growth, and abundant conventional resources encourage and enable continued use of conventional fossil fuels (IEA PV Technology Roadmap, 2009). China is working now to meet domestic demand and ambitious renewable energy targets by installing substantial new clean energy-generating capacity.

Since 2009, China's government has begun to promote eight wind power bases[1]. These wind park locations were identified taking into account partial resource assessments; they have rich wind resources on land and/or offshore. Furthermore wind power has been promoted in China since 2005 considering the technical and economic potential. China started to promote large-scale PV and CSP demonstration projects in 2010, however has not used high resolution solar resource assessments to support the development of these projects.

1 Wind Bases are very large wind parks, for example, the West Inner Mongolia Wind Bases will reach 20 GW wind capacity before 2020.

Table XVII Wind and Solar Energy Promotion Policy Instruments in China

National Policy	Goal	Nature	Instruments	Resources	Sector
Middle and Long-term Renewable Energy Development Strategy (2005-2020) "11th-Five-Year" Renewable Energy Development Plan National Development and Reform Commission (2005-2010)	10% Renewable Energy of total energy consumption by 2010 15% Renewable Energy by 2020 **Wind** – *M and L Strategy:* 5GW (2010); 30 GW (2020) – *11th- Plan:* 10GW (2010); 30GW (2020) **Solar PV** 300MW in 2010 1.8GW in 2020 **Solar water heating** 150 million m^2(2010) 300 million m^2(2020) Predicted national targets for solar power, solar thermal will be reached in 2010. Estimated wind power of at least double of national targets, 20GW in 2010, 60GW in 2020	Voluntary /Non-binding target	Several financial and legal instruments are proposed but not yet implemented	– Biomass – Wind – Solar – Small-scale hydro	– Electricity – Liquid fuels – Solar water heating
Regulation on Renewable Power Pricing and Cost Sharing (2006) National Development and Reform Commission	– To set-up the rational payback for renewable power developers, – Attract investment and increase the market scale of renewable power [1]	Compulsory	Financial tool – Subsidy on power price	– Solar – Wind – other renewable sources	Electricity
Special Fund on Localization Manufacturing of Wind Turbine (2008) Ministry of Finance	– To set-up the capital support for localization manufacturing of MW size wind turbine for Chinese enterprises, – To support the wind turbine industry development in China	Compulsory	Financial tool – Subsidy	Wind	Electricity

National Policy	Goal	Nature	Instruments	Resources	Sector
VAT Policy for Resource Comprehensive Utilization Projects (2001) Ministry of Finance and State Administration of Taxation	– To provide a favourable value-added-tax for comprehensive utilization of some resources and wind power projects, – Provide incentives for the development of wind the industry [2]	Compulsory	Financial tool – Tax	Wind	Electricity
Special Fund of Renewable Energy Development (2006) Ministry of Finance	To give financial support on the renewable energy development with large application potential and with products of replacing fuel, building heating and cooling, and electric power.	Compulsory	Financial tool – Subsidy	Solar and Wind	Electricity, fuel, thermal

(1) Bidding process for selecting the project developers. Generally, the project can get a subsidised power price of 20-30 RMB Yuan/MWh. Thus, a feed-in-tariff is adopted in China for renewable power. As a next step, it is suggested to provide detail financial and economic analysis for installed renewable power projects, and improve specific subsidy levels.

(2) The favourable VAT has provided real financial support for wind power projects. There is a shared view in the wind power industry that the VAT rate for wind power should be reduced further given its environmental benefits. However, the collected VAT is shared by the central government finance (75%) and local finance (25%), thus if the tax rate is too low, there will be less drive for the local government to develop wind power projects. Therefore, it is important to set the rational tax rate for this kind of policy.

In summary:

CHINA
Targets – China has set ambitious RE targets (not announced yet), to include a wind power target of 150 GW and a solar PV target of 20 GW by 2020. – The official targets fixed in the 2007 RE Medium and Long term Plan were a 15% share of renewables in primary energy made up as follows: 300 GW hydro, 30 GW wind, 30 GW biomass, 1.8 GW solar PV and 300 million m^2 of SHW by 2020.
Policies – Guaranteed prices determined by **bidding process**: Wind concession power (2003-2008) and large-scale PV has a guaranteed price through bidding since 2009. – Reduced **VAT income** tax measures for wind technologies. – **Feed-in-tariff for wind energy** since 2009, all other renewable energy technologies under the feed-in tariff as defined by the Renewable Energy Law (2005).The level of support is set by the provinces. – **Capital grants** through the Brightness Rural Electrification Programme.
Deployment – China is becoming an important global player in PV and wind, in terms of manufacturing capacity. However, PV production is vulnerable to changes in policies abroad as 95% of the produced technology is exported. – Without sufficient incentives, China is likely to follow a carbon-intensive development path.

Review of National Policies to Promote Solar and Wind Energy in South Africa

The non-binding target of 10,000 GWh of renewable energy contribution to the total energy consumption by 2013, as outlined in South Africa's White Paper on Renewable Energy (DME, 2003), raised awareness of renewables considerably. However, without adequate incentives, this target is unlikely to be reached. Unfortunately for the wind and solar electricity sectors, the renewable energy target was envisioned to be achieved through a mixture of sugar bagasse (59%), landfill gas (6%), hydro (10%), solar water heaters (13%), other biomass (1%) and only 1% wind; solar PV or CSP were not included (DME, 2004).

Several measures are being implemented to address this problem but until now implementation has not been effective. The most important measure to help meet the target is a feed-in tariff for renewable energy sources (REFIT) that was established in 2009. However, there is still no clarity on the process and a functioning REFiT does not seem to be advancing.

The Renewable Energy White Paper aims to eliminate barriers impeding the further promotion of renewable energies through a variety of initiatives, including: 1) promoting financial and fiscal instruments for redirecting national funds to renewable energies; 2) developing effective legislation in order to manage the growth of renewable energy; 3) promoting research and development of renewable energy projects; 4) raising public awareness; and 5) establishing technology support centres to assist in the maintenance of the new energy infrastructure. A description of national policies for promoting solar and wind energy is given in the table below.

Table XVIII Wind and Solar Energy Promotion Policy Instruments in South Africa

National Policy	Goal	Nature	Instruments	Resources	Sector
White Paper on Renewable Energy (2003) Department of Minerals and Energy	– Commits Government to ensure renewable energy becomes a significant part of its energy portfolio – Non-binding target of 10 TWh renewable energy of the total energy consumption by 2013. – 4% (1.7GW) of the projected electricity demand for 2013 (1)	Voluntary/Non-binding target	Several financial and legal instruments are proposed but not yet implemented	– Biomass – Wind – Solar – Small-scale hydro	– Electricity – Liquid fuels – Solar water heating
Renewable energy framework (2003) Department of Minerals and Energy	– Enable the establishment of new renewable energy generating projects to catalyse renewable energy market in order to meet South Africa's 2013 Renewable Energy target. – Non-binding target of 10 TWh renewable energy of the final energy consumption by 2013	Strategic short-term measure	i) IPPs proposals evaluated on competitive and least-cost basis ii) IPPs initiate the licensing process, IPPs contract includes a PPA iii) Eskom and municipalities buy renewable energy at production tariff and recover costs on pass through-basis iv) Projects developed as bilateral initiatives between IPP /customer paying generation premium will continue	– Biomass – Large Wind – CSP – Small-scale hydro	– Electricity

National Policy	Goal	Nature	Instruments	Resources	Sector
Renewable Energy Market Transformation Project (2009) Department of Minerals and Energy (DME) / Development Bank of Southern Africa	– Remove barriers and reduce implementation costs of renewable energy technologies to help mitigate GHG emissions – Promote on-grid electricity from renewable sources. – Establish policy and regulatory frameworks and provide technical assistance & build institutional capacity for Renewable Energy Power Generation and Commercial Solar Water Heating (2)	Voluntary	Renewable Energy Power Generation – Support: DME and NERSA to develop a legal, policy, and regulatory framework for renewable energy; – Financing mechanisms for covering the incremental cost of renewable; – Public and private sector institutional capacity for renewable investments. – Dissemination and Development of Resources information; – Matching Grants to strengthen the capacity of the private sector including: (i) activities for renewable investments; (ii) pre-feasibility studies for renewable investments; and (iii) promotion off-grid renewable energy. Commercial Solar Water Heating (CSWH): – Support the development of SWH industry to international best practice levels through technical assistance in developing standards and codes for CSWH, promotion campaigns, and training. – Matching and Performance Grants for small and medium enterprises	Renewables	– Electricity – Water heating
Long term mitigation scenarios (2007) Department of Environmental Affairs & Tourism /Energy Research Centre (U. of Cape Town)	– Outline different scenarios of mitigation action, – Inform long-term national policy – Provide a solid basis for South Africa position in multi-lateral climate negotiations	Policy making Support	Data-based scenarios	All resources	Energy

National Policy	Goal	Nature	Instruments	Resources	Sector
City of Cape Town – Energy and Climate Change Strategy (2006)	– Reduce climate change through the promotion of sustainable use of energy – Identify communities and ecosystems most vulnerable to the impacts of climate change in order to minimize these impacts. There may be some movement on a SWH initiative in CT later in 2011 where the city will recover the repayment of the SWH through their billing system.	Policy	Integration of sustainable energy approaches: – Development of strategic visions and goals – Capacity building – Transformation of energy supply – Energy efficiency programs – Setting of energy targets and monitoring/ enforcing them – Information gathering/management – Assessing vulnerability and adaption	Various	– Energy – Transport
Solar Water Heater By-law –(in planning) City of Cape Town Municipality	Regulate incorporation of SWH in all new buildings and all additions to existing buildings in Cape Town. In 2010 still not implemented	Compulsory	The bylaw will be implemented by means of building plan approvals.	Solar (3)	Water heating
Green Certificates – (2009) City of Cape Town Municipality	To sell electricity generated by Darling Wind Farm to customers in Cape Town Taking place from 2010	Voluntary	Green certificates (non-tradable)	Wind	Electricity
REFIT – NERSA (in planning)	Establish a feed-in tariff for renewable energy sources (4)	Compulsory	Feed-in tariffs	– Wind, – CSP, – hydro, -landfill gas	Electricity

(1) Targets were reviewed at the Renewable Energy Summit in Centurion on 19/20 March 2009.
(2) Four-year period, in line with GEF Operational Program No. 6.
(3) Heat pumps might be included in a revised version.
(4) The proposed tariffs are widely seen as too low to spur significant implementation of electricity generation from renewable sources.
IPP = Independent Power Producer
NERSA = National Energy Regulator of South Africa

In summary:

SOUTH AFRICA
Target Non-binding target of 10 TWh of renewable energy by 2013.
Policies – The White Paper on Renewable Energy (2003) aimed to remove barriers for the promotion of renewables and provide 10,000 GWh of RE by 2013. – **Feed-in Tariff** (REFIT) is the most important measure being implemented in 2009 but no Power Purchase Agreements were signed as of the end of 2010. While proposed by the National Energy Regulator of South Africa, the suggested feed-in-tariffs may not be high enough to stimulate significant investments (solar PV not included).
Use of resource assessment in governmental policies To date resources assessments have not been used in creating policy, except in the broader sense where it is recognised that ZA has significant solar resources and some wind and biomass potential. No high resolution wind atlas is available and none of the policies to date referred to any specific geographic area.

WIND AND SOLAR ENERGY TECHNOLOGIES

Brazil

The main applications of PV technology in Brazil are telecommunications, rural electrification, water pumping and public lighting in low-income rural communities. Grid-connected PV systems are still in the experimental stage, with a combined power of 22 kWp installed (Varella, 2009). In 1995, the Brazilian government launched a programme, PRODEEM (Programme of Energy Development of States and Municipalities), to promote rural electrification using PV systems. Approximately 9000 PV systems were installed from 1996 through 2001, with a total of 6 MWp of installed capacity. In 2003, the federal government launched the programme Luz para Todos (Light for All), which aims to provide electricity to the entire country by 2010. The programme has an estimated total budget of about USD 2.6 billion funded by the federal government, concessionaires and state governments. A programme for labelling PV equipment and systems was launched in 2003 by INMETRO (Brazilian Institute for Metrology, Standardisation and Industrial Quality) to guarantee the quality of equipment acquired and installed within the Light for All programme. This labelling scheme is currently in force and applies to PV modules, charge controllers, inverters and batteries and is done on a voluntary basis (Varella, 2008). The PV market is currently dominated by multinationals, and there are no domestic manufacturers. However, with the support of the government, the Brazilian Centre for Development of Solar PV Energy (CB-Solar), created in 2004, has developed a pilot plant to manufacture cost effective PV modules and silicon solar cells at scale (Moehlecke and Zanesco, 2007), (IEA PV roadmap, 2009).

BRAZIL	
WIND	**Total installed capacity** – 602.3 MW (2009) and 931 MW by the end of 2010. The largest installed capacity in Latin America until 2010 consisting of nearly 50% of the total capacity. – However, it is less than 3% of the potential capacity estimated for Brazil, 143.5 GW. – Total of 17 installed wind farms (2009), ranging from 0.3 MW to 50 MW. **Generating costs** Wind energy is already competitive with conventional sources (average of $0.08 /kWh); however, since the best locations are being used first, wind generating costs may rise again when the remaining locations are used. **Domestic production capacity** High-quality industrial capacity to produce wind turbines from 250 W up to 2.3 MW for domestic market and export (about 50% of annual production).
SOLAR	**Main solar energy technologies deployed** – More than 2.2 million square meters of solar water heaters installed for domestic use and small PV systems for off-grid applications. – Leading country in the use of PV for rural electrification. – Domestic production capacity of solar water heating industry is well developed. **Concentrating solar power (CSP)** No CSP plants or large PV systems are currently installed in the country.

China

China's solar PV industry has been growing rapidly and the country now ranks first in the world in exports of PV cells. Domestic output of PV cells expanded from less than 100 MW in 2005 to 2 GW in 2008, experiencing a 20-fold increase in just four years (Wang, 2008). This is the result of a strong demand from the international PV market, especially from Germany and Japan. However, the PV market demand in China remains small, with more than 95% of the country's PV-cell products exported.

In 2009, China's cumulative PV installed capacity was 305 MW (National Energy Administration, 2009). Some 40% of this demand is met by independent PV power systems that supply electricity to remote areas not connected to the national grid. Market shares of solar PV for communications, industrial, and commercial uses have also increased. BIPV systems, as well as large-scale PV installations in desert areas, are being encouraged by the Chinese government, which began providing a subsidy of RMB 20 (USD 2.93) per watt for BIPV projects in early 2009. It is likely that the 2010 and 2020 national targets for solar PV (400 MW and 1,800 MW, respectively) announced in 2007 will be significantly increased. Experts predict that the installed capacity could reach 1 GW in 2010 and 20 GW in 2020 in China (CREIA, 2009).

In early 2010, a deal was signed for at least 2 GW of CSP to be constructed in China by 2020, with installation of the first 92 MW to begin in 2010 (Renewable Energy World, s.f.).

CHINA	
WIND	**Installed capacity** – China is the world's largest market, with 13.8 GW added in 2009, more than one-third of the global market. – Wind capacity was doubled in 2009 in pursuit of an ambitious target of installing 30 GW of wind by 2020. **Domestic industry capacity** – Large-scale wind market is taking shape rapidly and the domestic industry is booming. – China remains the largest market for small wind turbines (2009).
SOLAR	**Installed capacity** – Total capacity of 305 MW in 2009 (1/3 provided by independent producers' off-national grid). – Major imbalance between PV production and domestic market. However, rapid expansion planned, setting up ambitious mid-term targets for domestic market, 1,800 MW installed capacity by 2020. **Domestic industry capacity** – PV industry has been growing rapidly; China is the world's leading ¬manufacturer of solar photovoltaic panels, with more than 40% share of global PV cell production in 2009 and about 50% in 2010. – 95% of production is exported. – Most raw materials and equipment are imported. **Solar Water Heaters** China dominates the world market with 70 % global installed capacity.
	CSP In early 2010, a deal was signed for at least 2 GW to be constructed in China by 2020, with installation of the first 92 MW to begin in 2010.

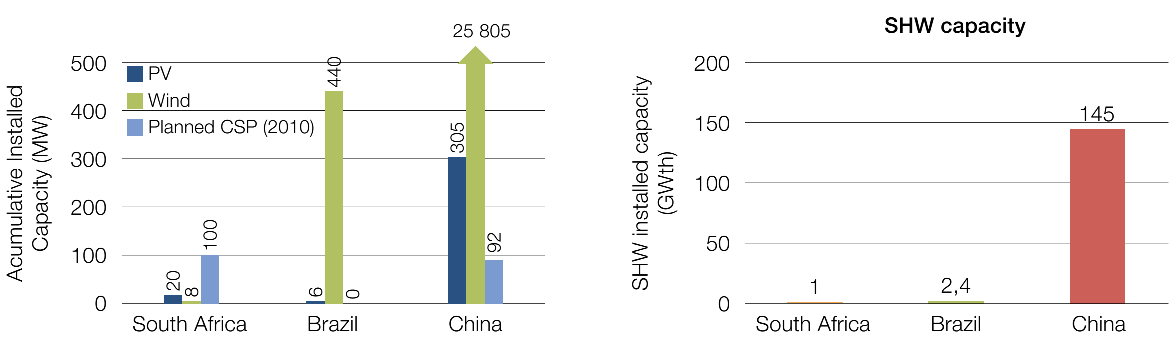
South Africa

South Africa's accumulative installed capacity for solar and wind technologies is very low despite abundant resources potentials and a national renewable energy feed-in tariff. There are only two wind farms in operation providing a capacity of 3.2 and 5.2 MW respectively. Solar energy applications are concentrated to domestic solar hot water heating, a strong sector that has received support through local mandates in Cape Town and a programme from the national utility, Eskom. The City of Cape Town solar water heating mandate is under consideration to be adopted at the national level. Renewables have a difficult playing field, as they forced to compete with cheaper conventional fuels, like coal, also in abundance in South Africa. In addition, Eskom, the only utility in southern Africa, enjoys a monopoly in the electricity sector.

It is expected that the feed-in tariff will help pave the way to making renewables more competitive with conventional (coal) produced electricity and will support the growth of renewables.

SOUTH AFRICA	
WIND	**Total installed capacity**. Two operational farms: – Klipheuwel 3.2 MW – Darling wind farm 5.2 MW Wind industry will boom with a viable feed-in-tariff.
SOLAR	**Domestic production capacity:** While the potential for solar is quite significant, the uptake of technologies has remained limited due to the lack of incentives. Main solar energy technologies being utilized are solar water heaters for domestic use (744.4MW_{th})and small PV systems for off-grid applications
	Large PV: No concentrating solar power plants or large PV systems are currently installed in the country.
	CSP: The only CSP installation was a 25 kW Stirling dish but it is out of operation. Eskom is planning a 100 MW solar tower near Upington, but finances have not been secured yet.

Figure 17 Accumulative Installed Capacity (2009) of Solar and Wind Technologies in Brazil, China and South Africa



PROJECT DEVELOPERS AND FINANCIERS

This section collects information from the major project developers and project financiers in each country about their data requirements for risk management of solar and wind energy projects. The section analyses the most influential barriers to investments in renewable energy technologies in the three countries such as renewable energy capacity, research and development, installation and maintenance, financial risks and initial costs.

Summary of Project Developers and Financiers in Each Country

BRAZIL
– Ranked sixth worldwide in investment in renewable energy (2009); total of US$ 7,400 million.
– Wind project developers made use of the existing wind energy resource assessment that indicates the best economic conditions are in the Northeast and South regions.
– Wind and solar energy policies have encouraged investment by companies mainly in wind energy (no investments in large PV).
– High-quality domestic industrial capacity to produce wind turbines.
– Traditionally dominated by just one turbine manufacturer, Wobben Enercon, several other international players have entered the Brazilian market, including Vestas, Suzlon and IMPSA.
– There are no national manufacturers on the PV market in Brazil, dominated by small PV systems.
– Companies expect to see new renewable energy policy measures resulting from Brazil's National Action Plan on Climate Change and suggest policies focus on bringing down the cost of renewable power generation, e.g. through a special tariff, renewable energy credits, or reduced transmission costs for smaller renewable energy generators (REEEP, 2010).

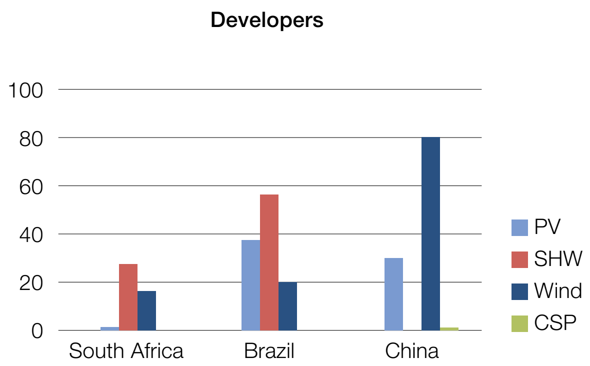
Source: (Pew Research 2010), (REEEP 2010)

CHINA
– Ranked first worldwide overall in investment in renewable energy (2009), total of US$ 34,600 million.
– National policy on renewable energy has provided a clear signal to companies and has stimulated investment.
– Companies would like to see innovation in energy market structure and demand management, e.g. a renewable energy generation obligation, a renewable energy or emissions trading market, generation-based subsidies.
– The Clean Development Mechanism (CDM) has stimulated corporate investment, both directly (e.g. for project development) and indirectly (e.g. new business areas for service companies).

Source: (Pew Research 2010), (REEEP 2010)

SOUTH AFRICA	
WIND	There are a large number of wind farm developers and two main wind farm financiers.
SOLAR	Main developers and financiers are municipalities and provincial governments for solar water heater roll-out programs.
– Ranked seventeenth worldwide in overall investment in renewable energy (2009) total of 125 million US$.	
– The Renewable Energy Feed-in Tariff (2009) is changing investment patterns, however there is uncertainty about how it will be applied; technology-specific measures not favoured. By the end of 2010, large number of wind farms, large scale PV and CSP plants as proposed REFIT projects but no Power Purchase Agreements (PPA) were signed under the REFIT. Main stumbling blocks are the development of mutually acceptable PPAs and the selection criteria used to assess and rank project proposals.	
– Industry would like to see R&D support, simplification of planning consents, renewable energy targets and in-country support for CDM project development (REEEP 2010).	
– Many financial institutions willing to provide loans for RE projects.	

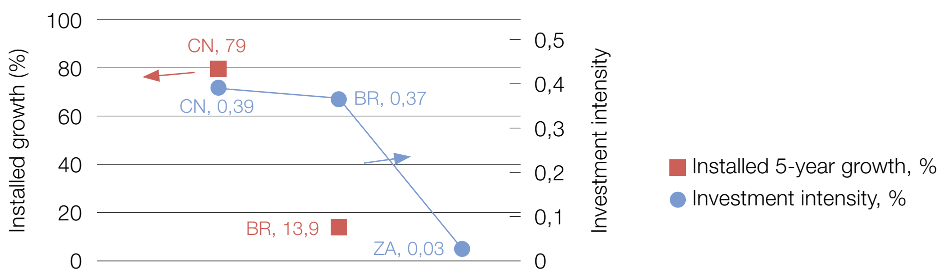
Figure 18 Solar and Wind Energy Developers in South Africa, Brazil and China



Each of the three countries have done consultations with solar and wind energy companies, financiers and developers to study the most influential risk criteria from their point of view such as the availability of resource information, standard approval or integration capacity of the existing grid.

In 2009 China was ranked third among G-20 nations, with 0.79 percent, and Brazil forth, with 0.37 percent, in clean energy investment intensity (clean energy investment as a percentage of gross domestic product) (Figure 19). The five-year growth in investment for Brazil and China is 148 percent each.

Figure 19 Investment Intensities in Renewable Energy Technologies (%) and Growth in the Installed Capacity (%) in Brazil (BR), China (CN) and South Africa (ZA)



Source: (Pew Research 2010)

Figure 20 Solar and Wind Energy Companies in South Africa, Brazil and China

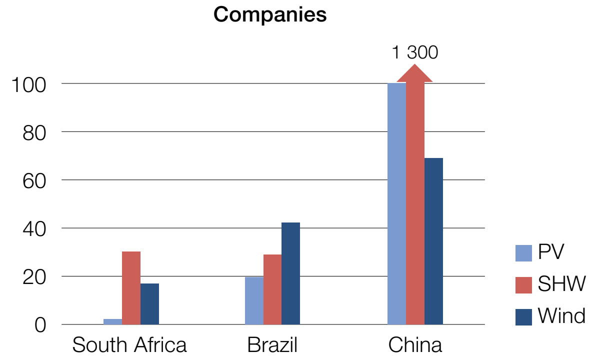
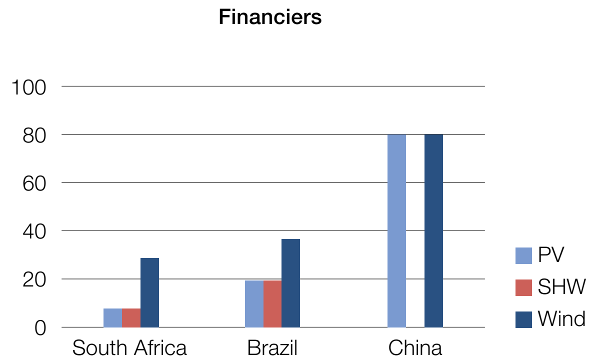


Figure 21 Solar and Wind Energy Financiers in South Africa, Brazil and China



Project Developers and Financiers in Brazil

The main PV solar energy project developers in Brazil are located in the South and Southeast regions of the country. Most of the PV systems developers are electricity utilities and research institutes. All of the systems installed are small and used for demonstration or educational purpose. Water heating is a major application of solar energy in Brazil. Government incentive programs were created to promote large-scale use of solar water heating systems. The major barrier to increase the adoption of solar water heating system is linked to the lack of information on this technology. Regarding wind energy, the criteria for risk management are similar for the 14 developers interviewed in Brazil.

Figure 22 Main Risk Criteria Identified by Wind Developers in Brazil

Very Important	Authorization to act as Independent Energy Producer by the Brazilian Agency for Electrical Energy.
Very Important	Proof of ownership for the area utilized or leasing contract for a period not less than 20 years.
Very important	At least 60% of the plant value in equipment and services should be manufactured in Brazil. Must be qualified as an energy producer and able to obtain governmental loan and other benefits regulated by Law.
Very important	The grid should be able to cope with the additional electricity being fed into the grid according to the National operator of Electrical System or utilities.
Very important	Environmental License issued by Brazilian Ministry of Environment or other authorized state institute.
Very important	Reliable wind measurements for at least one full year certified by an independent wind energy auditor accredited according to IEA rules. It is very important to evaluate the project's economic feasibility.

Figure 23 Main Risk Criteria Identified by Wind Financiers in Brazil

Very Important	Technology, products and services generated by R&D projects.
Very Important	Increase the scope of the distribution services of electricity.
Very important	Wind farms should be in accordance with the PROINFA requirements regulated by Law no. 10438.
Very important	The Ministry of Mines and Energy should announce the wind farm project as Enable to PROINFA.
Very important	Performance status of other renewable energy projects in developing countries.
Very important	Energy companies meet the Brazilian rules for receiving straight grants.

Project Developers and Financiers in South Africa

Wind resources are considered a key risk criterion to take into account during the development of wind farms as resources must allow for a capacity factor greater than 30%.

Figure 24 Risk Criteria Identified by Wind Farm Developers in South Africa

Neutral	Important	Very important
		Grid able to cope with additional wind electricity
	Wind farm distance to grid ≤ 30 km	Terrain should be environmentally sound
Wind farm not located in area where communication media are already in place	Terrain accessible for construction	Capacity factor has great influence on electricity costs: Wind resources must allow capacity factors $\geq 30\%$

SHW developers do not identify solar resources as a risk factor, and it is not a factor considered in the development of SHW projects, although a survey of the SHW industry shows that 90% of the enterprises take into consideration different solar resource assessments and use software tools.

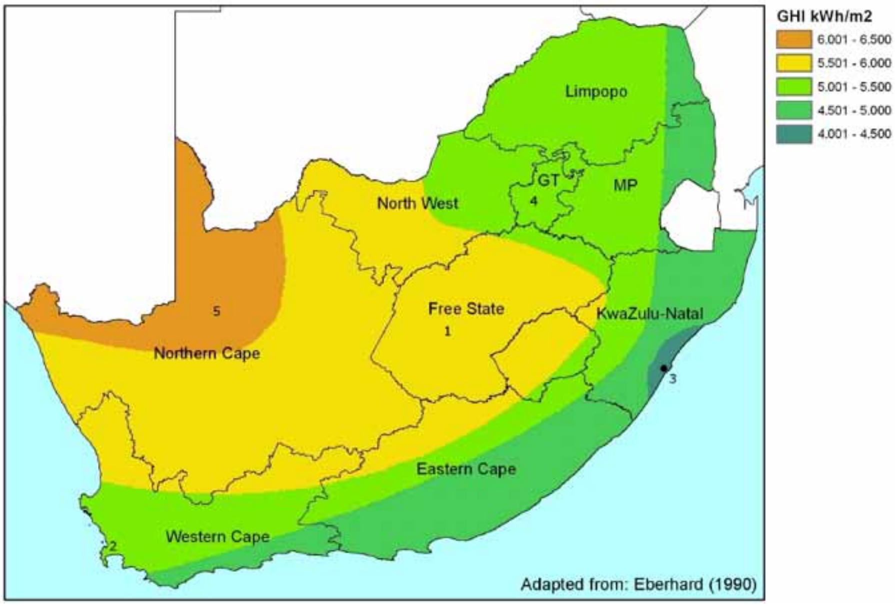
Figure 25 Risk Criteria Identified by SHW Developers in South Africa

Less important	Neutral	Important	Very important
	Standards approval		
Water pressure	Vandalism		
Transport and storage	Shortage of materials	Shortage of installers	
Climate conditions	House conditions	Identification of recipients	Appointment of service provider

ANNEX I: AVAILABLE SOLAR AND WIND MAPS

Available Solar and Wind Resource Assessments in South Africa

Figure 26 A Solar Radiation Data Handbook for Southern Africa



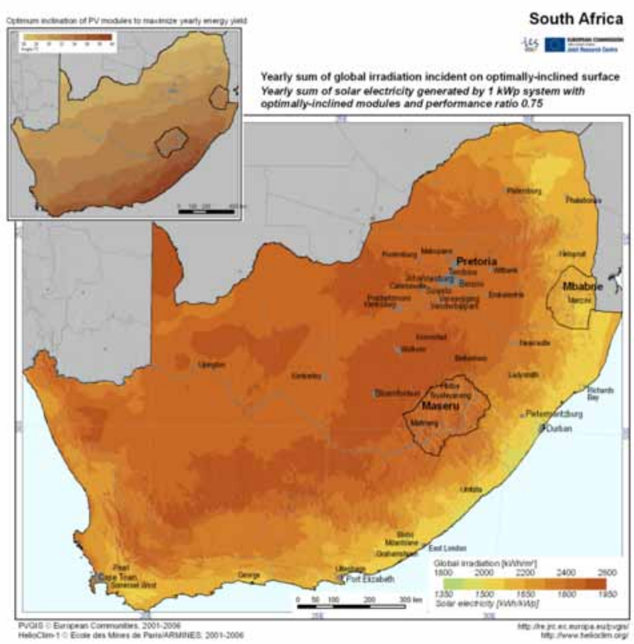
A solar radiation data handbook for Southern Africa	Available Free
Author/Publisher	Eberhard, A., University of Cape Town/Energy Research National Programme – Foundation for Research Development
Methodology	Interpolation between measuring stations: – Global and diffuse radiation from 12 stations – Sunshine hour from 86 stations.(1)
Main Findings	– Low resolution maps of global radiation for South Africa and Namibia – The data are presented in contour maps, bar-charts and tables
Link to publication	Contact anton.eberhard@gsb.uct.ac.za

(1) Where only sunshine hour records were available, the values for global radiation were estimated.

Figure 27 Climate of South Africa – Sunshine and Cloudiness

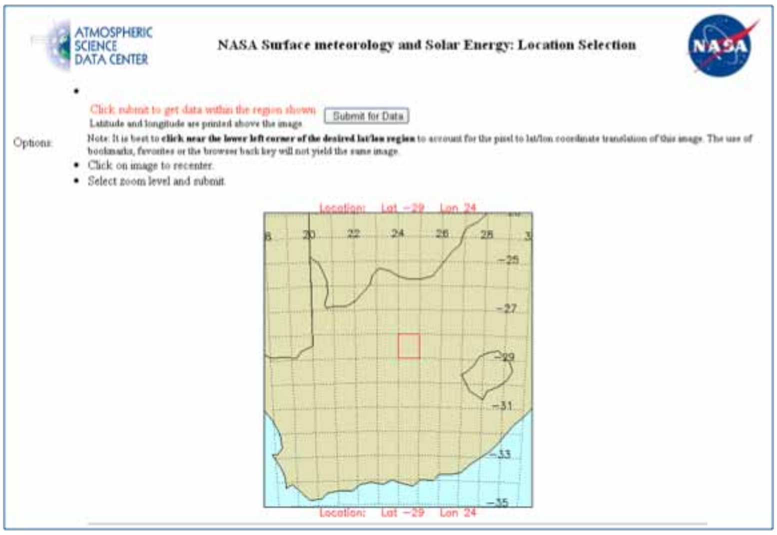
Climate of South Africa – Sunshine and cloudiness	Available Free
Author/Publisher	South African Weather Service
Methodology	Interpolation between measuring stations: Sunshine hour from 13 stations were use
Main Findings	Seeks to distinguish between areas of different **sunshine climates** as well as **cloudiness** – Sunshine hour maps: The data are presented in contour maps, tables and plots. – No region receives less than half of the possible sunshine, and a very large region in the interior receives over 80 %.
Link to publication	http://old.weathersa.co.za/Publications/Documents/Public_General_info_Publications.doc

Figure 28 PVGIS-JRC European Commission



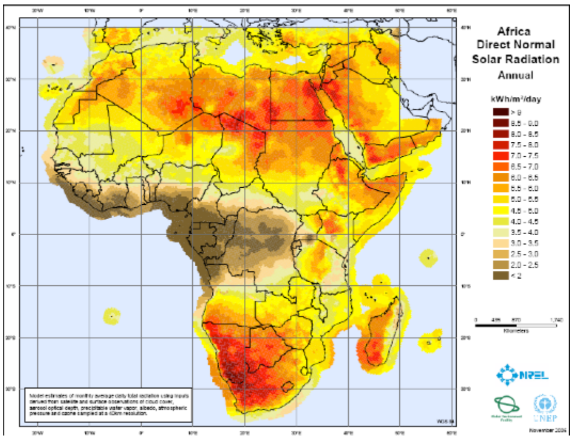
PVGIS-JRC European Commission	Available Free
Author/Publisher	Joint Research Centre (JRC), European Commission
Methodology and Resolution	A GIS-based methodology for computation of solar irradiance/irradiation at a given surface inclination
Main Findings	Map-based inventory of solar energy resource and assessment of the electricity generation from photovoltaic systems
Link to publication	http://re.jrc.ec.europa.eu/pvgis/apps3/pvest.php?map=africa

Figure 29 Nasa: Surface Meteorology and Solar Energy



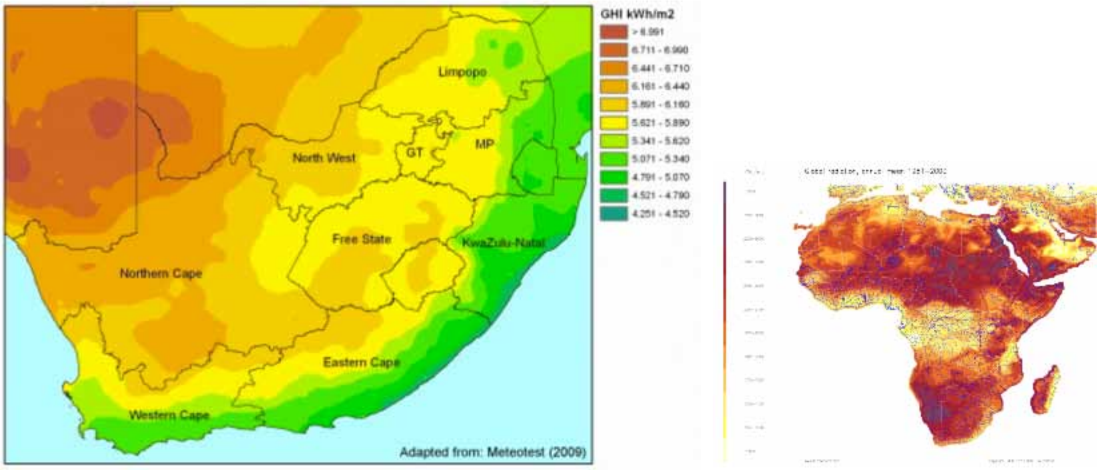
NASA: Surface Meteorology and Solar Energy	Available Free
Author/Publisher	NASA's Earth Science Enterprise Program
Methodology and Resolution	Low resolution map (1 degree longitude x 1 degree latitude) Meteorology and solar radiation f from the NASA Science Mission Directorate's satellite and re-analysis research programs.
Main Findings	Interactive maps: *A renewable energy resource web site*
Link to publication	http://eosweb.larc.nasa.gov/cgi-bin/sse

Figure 30 Swera – Solar and Wind Energy Resource Assessments



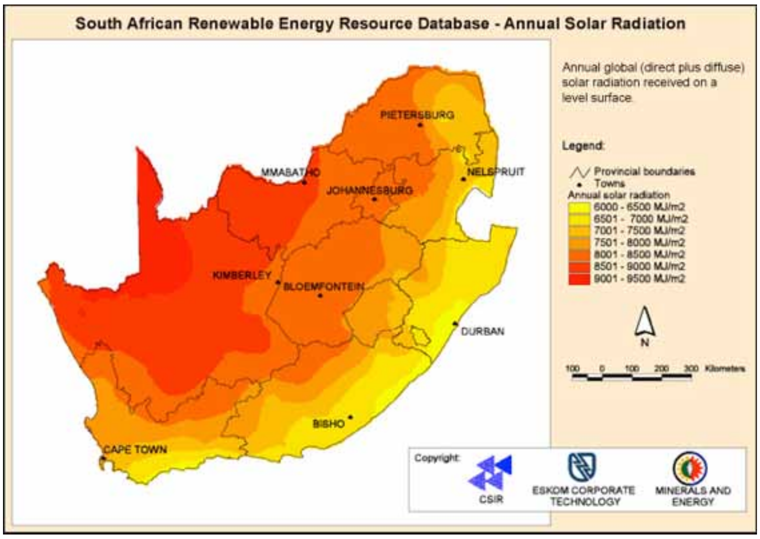
SWERA – Solar and Wind Energy Resource Assessments	Available Free
Author/Publisher	NREL/UNEP,GEF
Methodology and Resolution	Low resolution map (40km x 40km) NREL's Climatological Solar Radiation Model uses information on cloud cover, atmospheric water vapour and trace gases, and the amount of aerosols in the atmosphere to calculate the monthly average daily total insolation (sun and sky) falling on a horizontal surface.
Main findings	Solar resource data for Africa: monthly and annual average direct normal (DNI), global horizontal (GHI), latitude tilt, and diffuse data and GIS data at 40 km by 40 km resolution for Africa.
Link to publication	http://swera.unep.net

Figure 31 Meteonorm



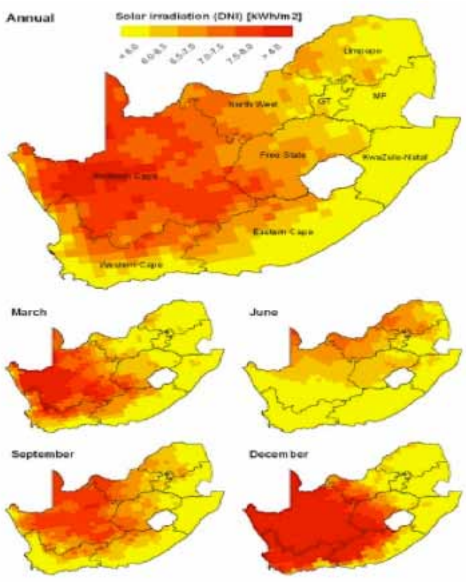
Meteonorm	
Author/Publisher	Meteotest, Switzerland
Methodology and Resolution	The programme's calculation algorithms provide the basis for generating hourly values for global radiation, temperature and other meteorological parameters. Satellite data is used in areas with a low density of weather stations.
Main findings	Database with climatic data from 8055 stations around the world (29 stations in South Africa of which only 11 provide solar radiation data)
Link to publication	http://www.meteonorm.com/media/maps_online/gh_map_africa.pdf

Figure 32 South African Renewable Energy Resource Database – Annual Solar Radiation. ESKOM



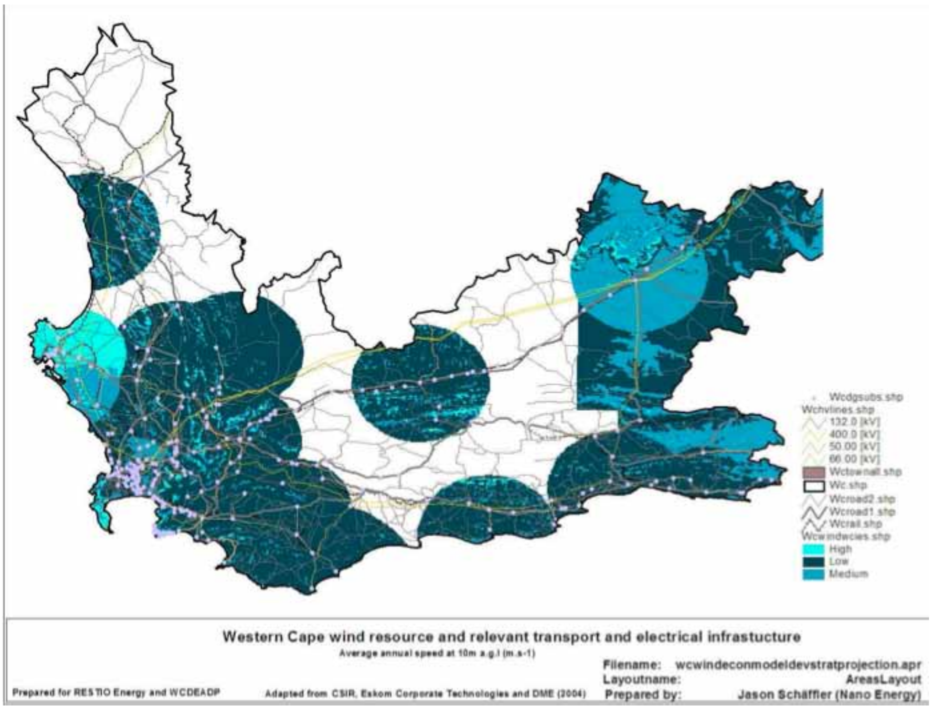
SA Renewable Energy Resource Database	Available Free
Author/Publisher	ESKOM
Resolution and Methodology	Low Resolution Annual Solar Radiation Map Model estimates total or global radiation based on 1 geometric and 1 atmospheric component. Total radiation estimated by adjusting predictions from the geometric model by the transmissivity predicted by the atmospheric model
Main Findings	– Low resolution map with annual global horizontal irradiation – Solar radiation data, collected over a 40 year period at 130 sites by the South African Weather Bureau, used to create/verify the various model components.
Link to publication	http://www.crses.sun.ac.za/pdfs/Solar%20Mapping%20SA-1.pdf http://www.erc.uct.ac.za/seminars-courses/presentations/Fluri_19-08-2009.PDF

Figure 33 CSP Study



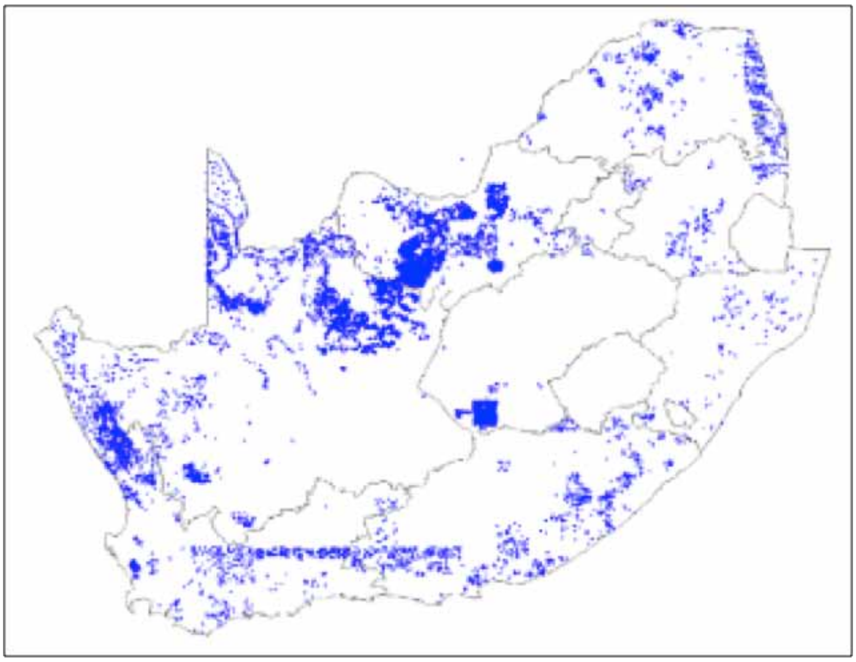
CSP study-T.P. Fluri	Available Free
Source	T.P. Fluri/Energy Policy 37 (2009) 5075–5080
Resolution and Methodology	Low resolution map (40 kmx40km)
Link to publication	http://www.crses.sun.ac.za/UNEP/Additional%20-%20TP%20Fluri%20The%20potential%20o%20fconcentrating%20solar%20power%20in%20South%20Africa.pdf
Main Findings	Maps derived from NREL data showing the average daily direct normal irradiation (DNI) for the whole year and for the months of March, June, September and December

Figure 34 A Proposed Renewable Energy Plan of Action for the Western Cape Assessment



A Proposed Renewable Energy Plan of Action for the Western Cape	Available Free
Author/Publisher	Nano Energy
Resolution and Methodology	High for the west coast, Medium for the rest of the province Overlay created from physical data
Main Findings	Wind map of Western Cape
Link to publication	http://www.capegateway.gov.za/Text/2008/3/4._ses_re_banks_resources_scenarios_plan_drafoctt20070523v5_print.pdf

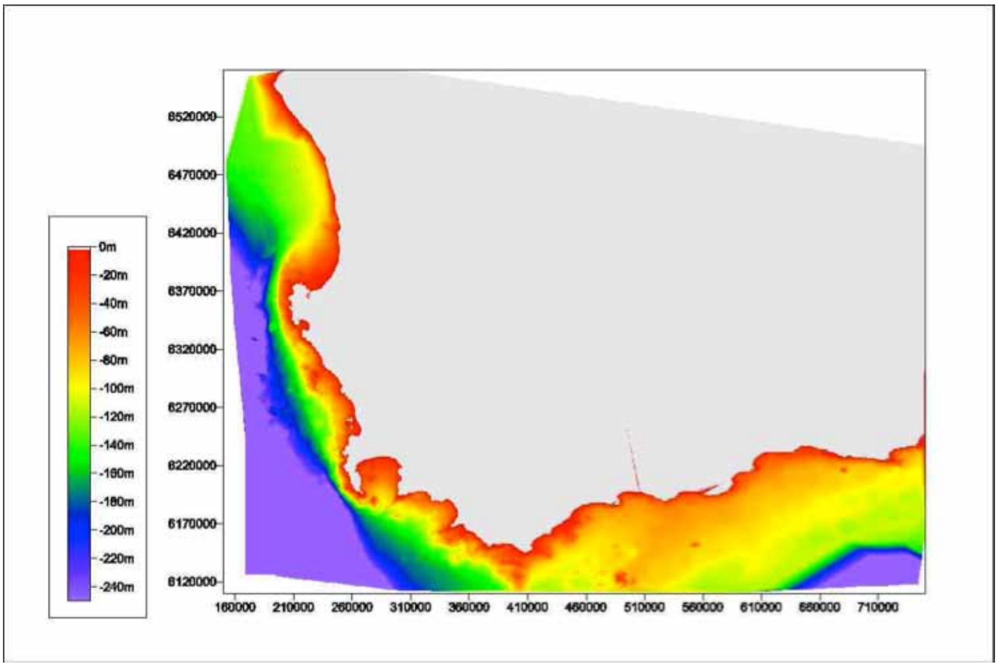
Figure 35 Baseline Study on Wind Energy in South Africa



Windmill in use for Water pumping in South Africa

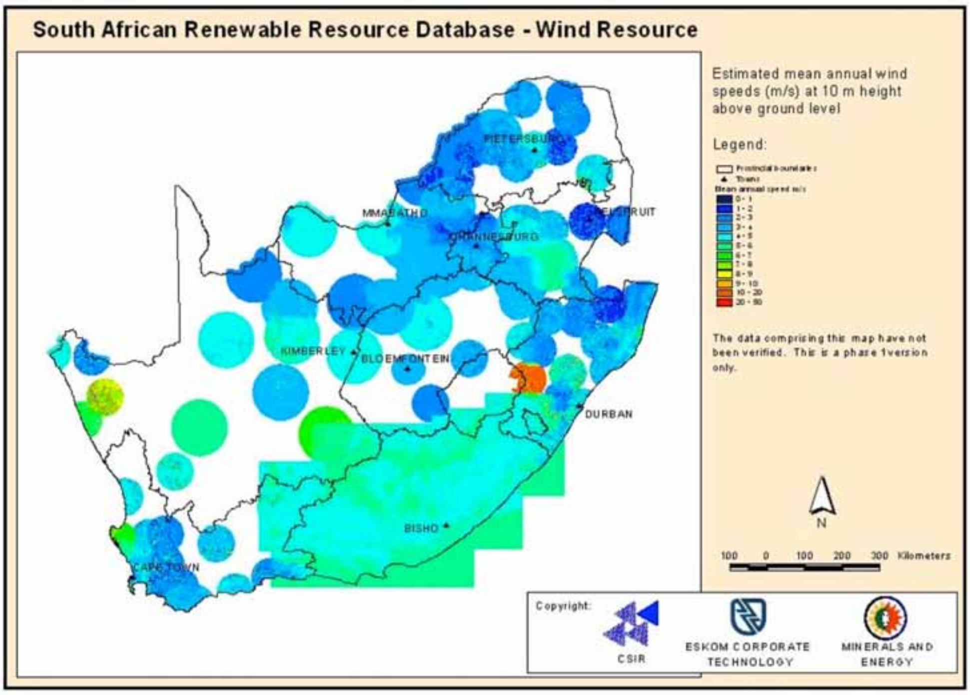
Baseline Study on Wind Energy in South Africa	Available Free
Author/Publisher	Department of Mineral and Energy
Methodology	Statistical data: Collection and processing of statistical and other information pertaining to wind energy systems currently installed in South Africa
Main Findings	Current utilisation of wind power in South Africa
Link to publication	http://www.wwindea.org/home/images/stories/wwecs/docs/2003/windbaselinestudy.pdf

Figure 36 Review of Wind Energy Resource Studies in South Africa



Review of Wind Energy Resource Studies in South Africa	Available Free
Author/Publisher	Department of Mineral and Energy
Methodology	Report: Various sites visited and the accuracy or validity of existing wind maps are assessed against actual measurements
Main Findings	Predicting the wind resource from meteorological stations must be done with caution and high uncertainty is expected
Link to publication	http://unfccc.int/files/meetings/seminar/application/pdf/sem_sup1_south_africa.pdf

Figure 37 South African Renewable Resource Database – Wind Resource/Eskom



South African Renewable Resource database – Wind Resource	Available Free
Author/Publisher	Eskom
Resolution	Low resolution map with estimated mean annual wind speed at 10 m
Main Findings	Patchy Wind map of South Africa
Link to publication	http://www.sabregen.co.za/sarerd%20database/wind.htm

Figure 38 Bulk Renewable Energy Independent Power Producers in South Africa

Bulk Renewable Energy Independent Power Producers in South Africa	Available Free
Sponsor/Author/Publisher	Danish Cooperation for Environment and Development/Department of Mineral and Energy

Figure 39 Resource and Technology Assessment-KwaZulu Natal

Bulk Renewable Energy Independent Power Producers in South Africa	Available Free
Author/Publisher	RAPS Consulting
Methodology/Resolution	From published maps, it is difficult to determine the speed at specific sites
Main Findings	From published maps it is difficult to tell speed at specific sites
Link to publication	http://www.nura.co.za

Figure 40 Renewable Energy Briefing Paper: Potential of Renewable Energy to Contribute to National Electricity Emergency Response and Sustainable Development

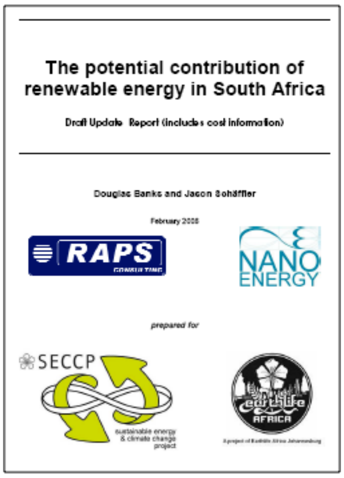

Renewable Energy Briefing Paper

Potential of Renewable Energy to contribute to National Electricity Emergency Response and Sustainable Development

Executive summary

Renewable Energy Briefing Paper	Available Free
Author/Publisher	Holm, D., Banks, D., Schäffler, J., Worthington, R., and Afrane-Okese, Y
Methodology/Resolution	No map. Based on prior works by Banks and Schäffler (2007)
Main Findings	Reference paper not containing resource information just with reference to them. Public information is moderate quality
Link to publication	http://www.nano.co.za/REBriefingPaperFinal5Aug08.pdf

Figure 41 The Potential Contribution of Renewable Energy in South Africa/DANIDA



The potential contribution of renewable energy in South Africa

Draft Update Report (includes cost information)

Douglas Banks and Jason Schäffler

RAPS

NANO ENERGY

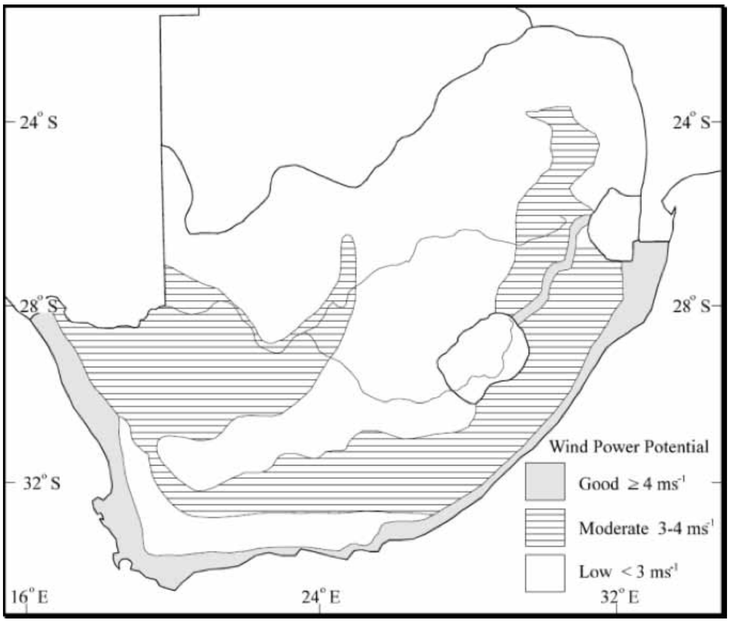
prepared for

SECCP

sustainable energy & climate change project

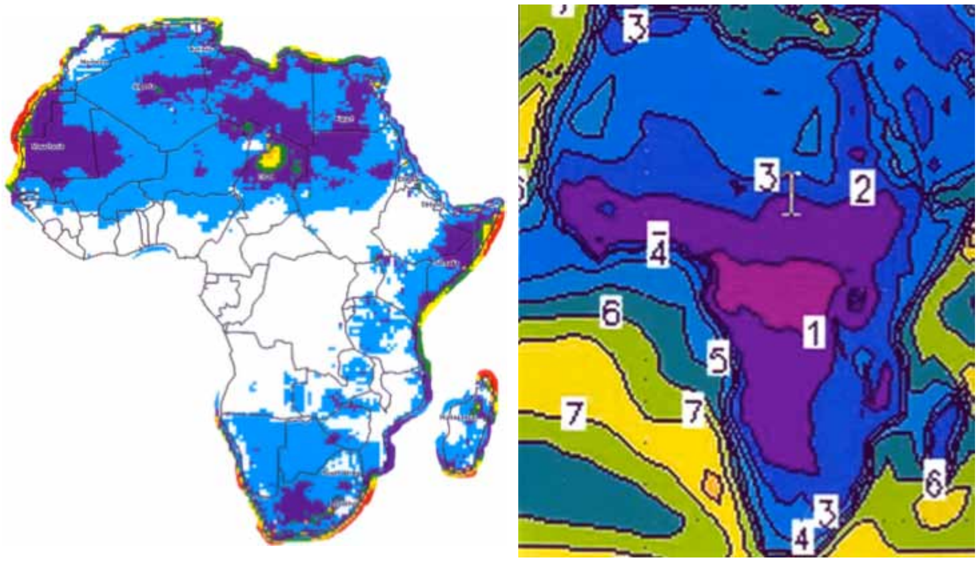
The potential contribution of renewable energy in South Africa	Available Free
Author/Publisher	Sustainable Energy & Climate Change Project /DANIDA
Methodology/Resolution	Resource from available studies
Main Findings	Low resolution Wind Map
Link to publication	http://www.nano.co.za/PotentialContributionOfRenewableEnergyInSAFeb06.pdf

Figure 42 Wind Atlas of Southern Africa



Wind Atlas of Southern Africa	Available Free
Author/Publisher/Sponsor	R.Diab-U. KwaZulu Natal/Department of Minerals and Energy
Resolution	Low resolution wind map for South Africa. Western Cape coast line given in more detail
Main Findings	Wind data from variety of sources was collected and synthesised to assess wind potential
Link to publication	Contact diab@ukzn.ac.za

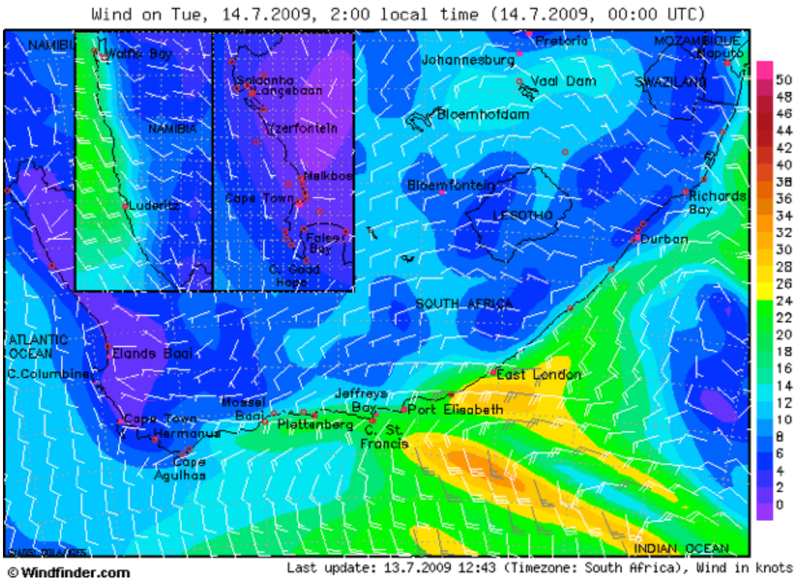
Figure 43 Wind Engineering in Africa

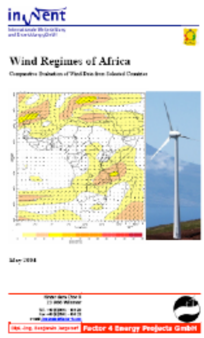


Annual mean wind speed in m/s, 50m a.g.l. in m/s as generated, with a grid of 50km (African Development Bank, 2004
Detail of a world map of annual mean wind speed in m/s, 10m a.g.l. for the period 1976–1995 (WAsP, 2006).

Wind Engineering in Africa	Elsevier fee
Author/Publisher	J. A. Wissea, K.StigterTechnical University Eindhoven
Resolution and Methodology	Low (50kmx50km) at 50 m mean wind speed at 10 m WaSP
Main findings	Wind maps of Africa from different resources
Link to publication	http://www.sciencedirect.com

Figure 44 Wind Regimes in Africa/African Wind Energy Association

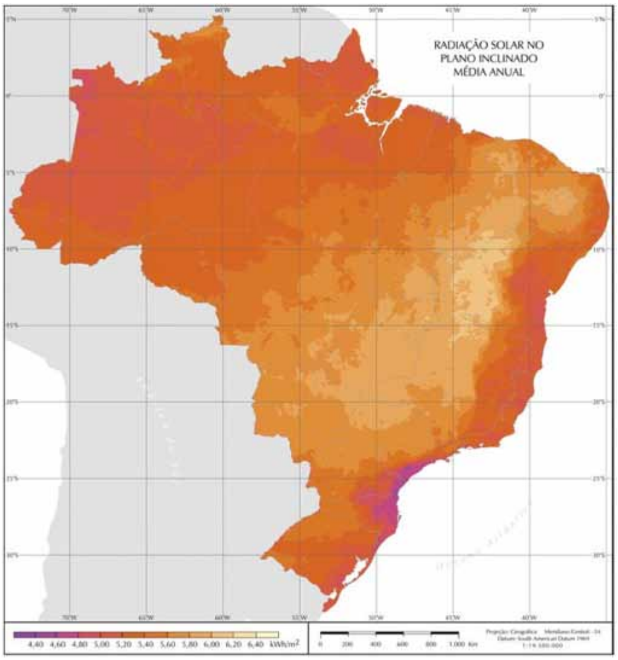


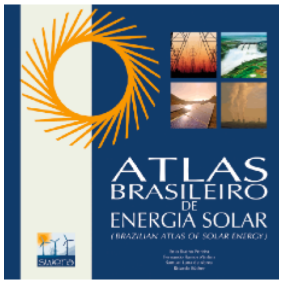


Wind Regims In Africa Map	Available Free
Author/Publisher	African Wind Energy Association
Resolution and Methodology	Low resolution maps WINDPLOT
Main Findings	Wind map based on measured data see Wind Atlas of South Africa (Diab, 1995)
Link to publication	http://www.afriwea.org/

Available Solar and Wind Resource Assessments in Brazil

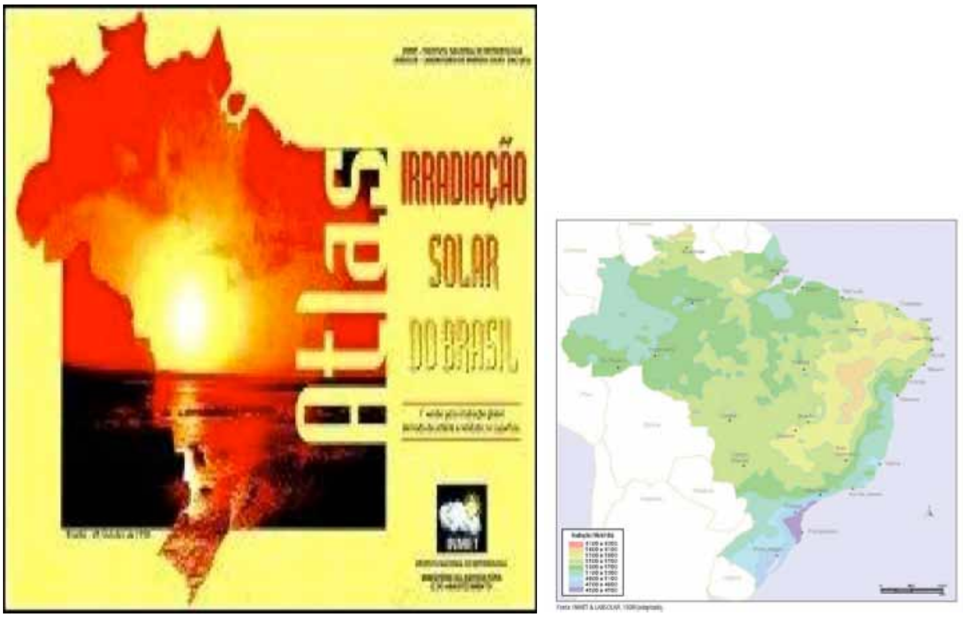
Figure 45 Brazilian Atlas for Solar Energy – INPE/SWERA





Brazilian Atlas for Solar Energy	Available Free
Author/Publisher	INPE/SWERA
Resolution and Methodology	Radiative transfer model BRASIL-SR and a geo-referenced environmental and socio-economic database.
Main findings	– Digital and printed maps of global, diffuse, normal direct and PAR components of solar irradiation. – Solar energy scenarios prepared by GIS tools. – Typical meteorological year for main Brazilian cities.
Link to publication	http://swera.unep.net/ and http://sonda.ccst.inpe.br/publicacoes/

Figure 46 Solar Radiation Atlas of Brazil – Brazilian Institute For Meteorology

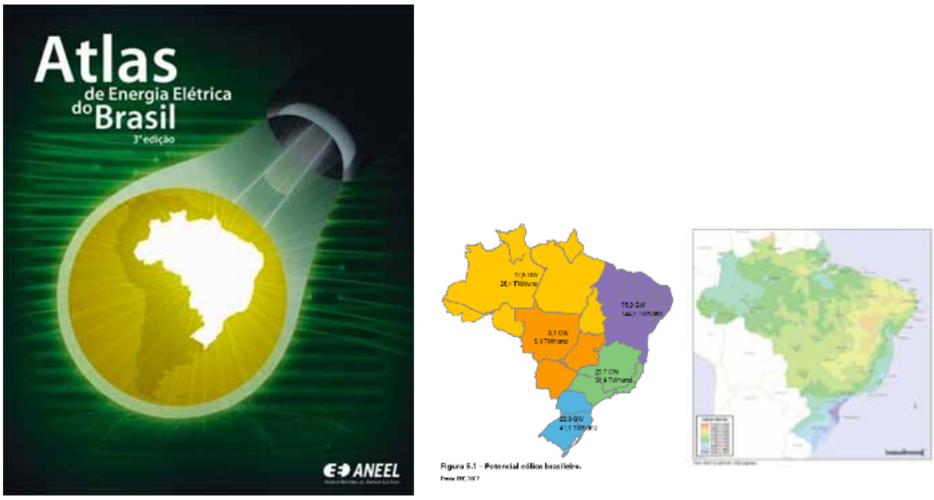


Solar Radiation Atlas of Brazil	R$ 30
Author/Publisher	Brazilian Institute for Meteorology (INMET)
Resolution and Methodology	50km x 50 km Estimates provided by BRASIL-SR model based on satellite data
Main Findings	All solar irradiation components (global, diffuse and normal direct) presented in maps and charts.
Link to publication	http://www.inmet.gov.br/html/informacoes/publicacoes/

Figure 47 Brazilian Solarimetric Atlas Ground Database – CRESESB

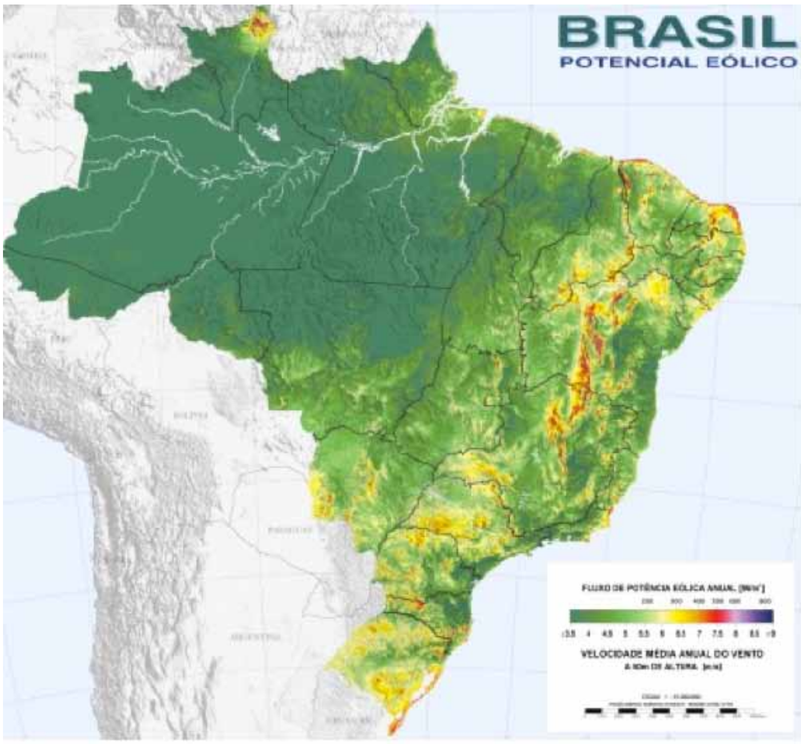
Brazilian Solarimetric Atlas Ground Database	R$ 30
Author/Publisher	CRESESB/CEPEL
Methodology	Ground data acquired by pyranometer and actinographer at over 500 sites.
Main Findings	Contour-line maps: Isolines Charts and Maps: daily and monthly global solar irradiation and insolation.
Link to publication	http://www.cresesb.cepel.br/

Figure 48 Brazilian Atlas of Electricity (3rd Edition)/Brazilian Agency for Electric Energy



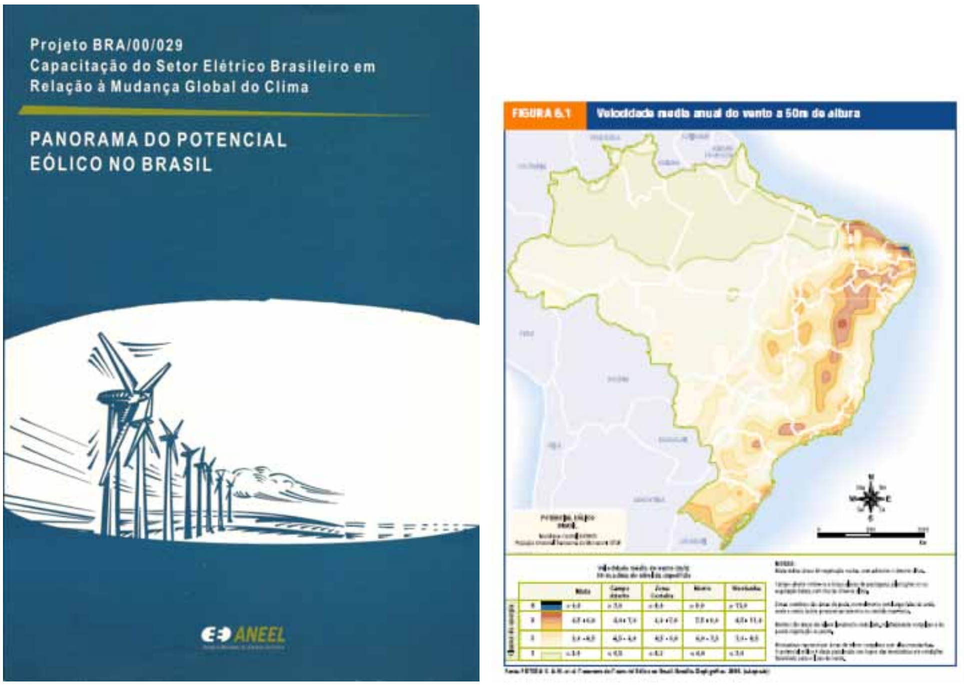
Brazilian Atlas of Electricity	Free
Author/Publisher	Brazilian Agency for Electric Energy
Resolution and Methodology	Statistical data and low resolution map collection – Collection of data (1998-2002): electricity generation and consumption, demographic census, energy utilities and stakeholders, government and private organizations
Main Findings	– Targets and forecasts for conventional and alternative energy sources for electricity generation. – Production, transmission and distribution of electric energy, it's socio-economic and environmental impacts.
Link to publication	http://www.aneel.gov.br/visualizar_texto.cfm?idtxt=1689

Figure 49 Atlas Do Potencial Eólico Brasileiro CRESESB/CEPEL



Atlas do Potencial Eólico Brasileiro	Available Free
Author/Publisher	CEPEL/CRESESB
Resolution and Methodology	1kmx1km 45 ground sites -Anenometers at 50m height Numeric modelling with mesoscale model MASS/MesoMap together with limit-layer model WindMap.
Main Findings	– Wind potential map. – Maps of annual and seasonal average for wind velocity and direction. – Weibull parameters.
Link to publication	http://www.cresesb.cepel.br/atlas_eolico_brasil/mapas_1a.pdf

Figure 50 Wind Energy Overview for the Brazil/ANEEL

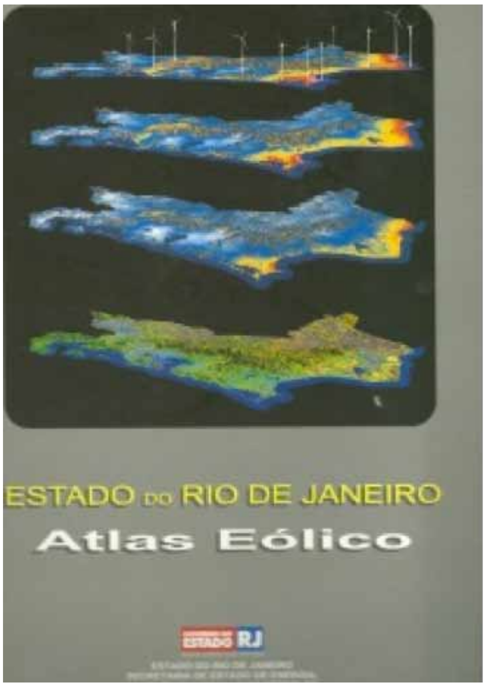


Wind Energy Overview for the Brazil	Available Free
Author/Publisher	ANEEL
Resolution and Methodology	1kmx1km. 45 ground sites -Anenometers at 50m height Numeric modelling by using mesoscale model MM5 together with WAsP
Main Findings	– Annual and seasonal wind velocity and direction at 50m high
Link to publication	final report for the PNUD project at http://www.dsr.inpe.br/projetofurnas/doc/RelFProj029.pdf

Figure 51 Wind Energy Atlas for the Rio Grande Do Sul

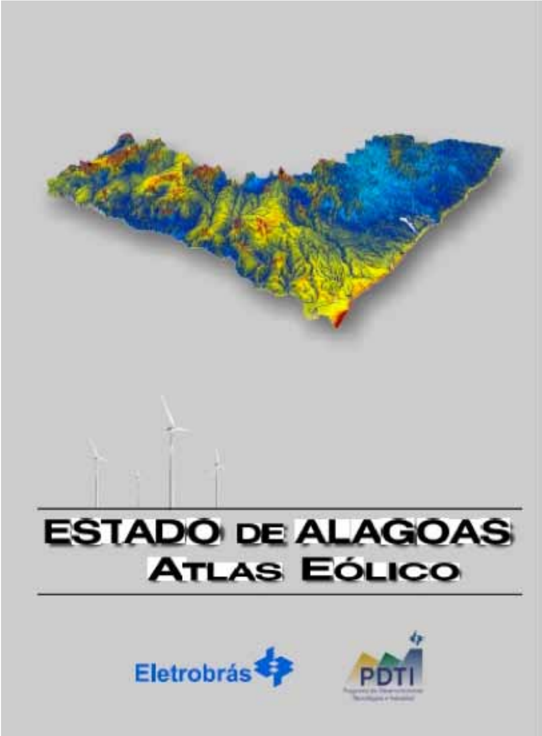
Wind Energy Atlas for the Rio Grande do Sul	Available Free
Author/Publisher	ANEEL
Resolution	1kmx1km 45 ground sites -Anenometers at 50m height Anemometers data acquired and numeric modelling with mesoscale model MASS/MesoMap together with limit-layer model WindMap.
Main Findings	– Wind potential map – Thematic maps for annual and seasonal wind speed average and direction at 50m, 75m, and 100m (daytime regime). – Weibull distribution parameters.
Link to publication	http://www.seinfra.rs.gov.br/atlas/INDEX_mapas.htm/ http://www.seinfra.rs.gov.br/index.php?menu=atlaseolico/

Figure 52 Wind Energy Atlas for the Rio De Janeiro



Wind Energy Atlas for the Rio de Janeiro	Available Free
Author/Publisher	State Government of Rio de Janeiro-SEINPE
Resolution	200mx200m Anemometers data acquired and numeric modelling with mesoscale model MASS/MesoMap together with limit-layer model WindMap
Main findings	– Wind potential map – Thematic maps for annual and seasonal average of the wind speed and direction for 50m, 75m, and 100m height, daytime regime). – Weibull distribution parameters
Link to publication	http://www.forumdeenergia.com.br/nukleo/pub/atlaseolicorj.zip

Figure 53 Wind Energy Atlas for Alagoas – Eletrobras

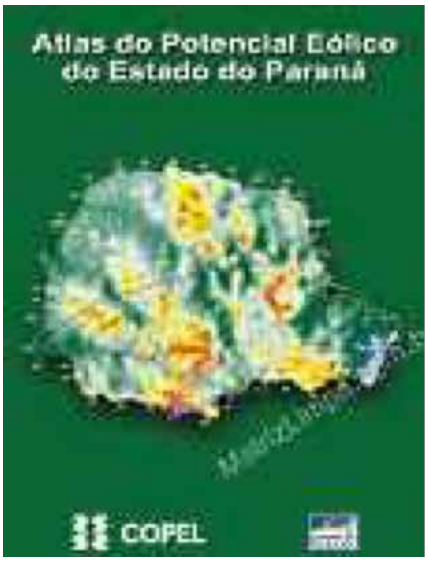


Wind Energy Atlas for Alagoas	Available Free
Author/Publisher	ELETROBRAS, Technology Institute for Development and University of Alagoas (UFAL).
Resolution	High resolution: 90m x 90m
Main Findings	– Identifies three areas for wind energy exploitation ; – The wind energy potential is estimated at 336MW in areas with wind velocity larger than 7 m/s at 75 m high.
Link to publication	http://www.desenvolvimentoeconomico.al.gov.br/minas-e-energia/mapa-eolico/

Figure 54 Wind Energy Atlas of São Paulo – Metropolitan Company for Water and Energy

Wind Energy Atlas of São Paulo	Available Free
Author/Publisher	Metropolitan Company for Water and Energy
Resolution and Methodology	High resolution: 200m x 200m 7 wind towers between 50m to 100m WAsP/KAMM method.
Link to publication	Wind Energy Atlas in progress

Figure 55 Potential Wind Atlas of the State of Paraná

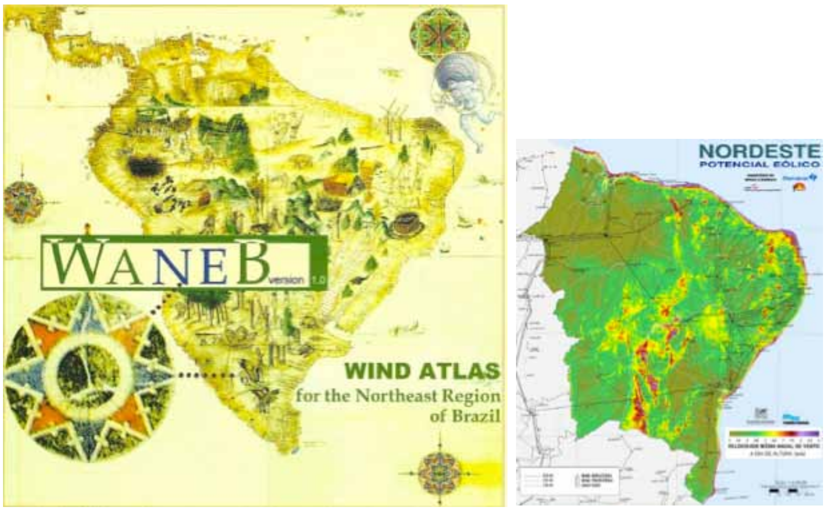


Potential Wind Atlas of the State of Paraná	N/A
Author/Publisher	COPEL – Companhia Paranaense de Energia
Resolution and Methodology	High resolution: 100m x 100m 34 wind farms (one 100 m height)
Link to publication	http://www.matrizlimpa.com.br/wp-content/plugins/download-monitor/download.php?id=Atlas_do_Potencial_Eolico_do_Estado_do_Parana-MatrizLimpa.com_.br_.pdf.zip
Main Findings	– Central Southern area: best potential wind sites. – Northern and Western regions present a larger wind resource than pre-estimated – The wind electricity generation in Paraná can reach 3.375 GW-40% of the consumption in Paraná

Figure 56 Wind Atlas of Maranhão

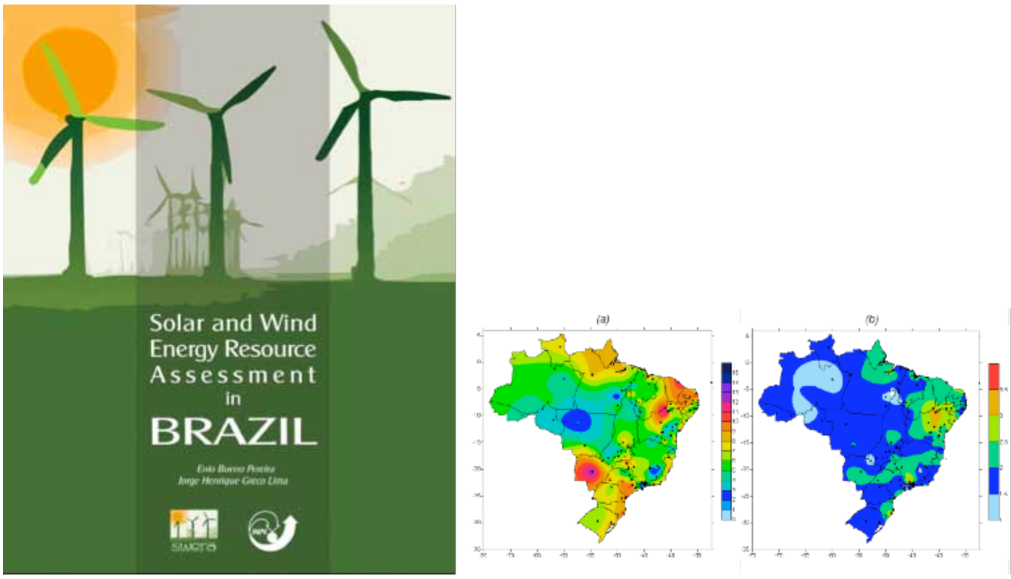
Wind Atlas of Maranhão	N/A
Author/Publisher	State Government of Maranhão and University of Maranhão
Resolution	In progress
Link to publication	In progress

Figure 57 Wind Atlas for the Northeast Region of Brazil – ANEEL



Wind Atlas for the Northeast Region of Brazil	Free
Author/Publisher	ANEEL -WANEB
Methodology	34 wind farms (one 100 m height). – Preliminary wind assessment using reliable wind data from the Brazilian Wind Energy Centre, electricity companies and selected meteorological stations – Dynamical numerical model for typical wind climate
Main Findings	– Contour line maps – Description of trade wind front trajectory and modelling for wind power applications; – Characterization of the meso-scale wind circulation, – Identification of the regional windy areas for installing wind turbines; – Classification of the regional roughness length for wind energy application, using remote sensing analysis; – Modelling land-sea breeze circulation and daily speed variation;
Link to publication	http://www.eolica.com.br No digital copy available in internet

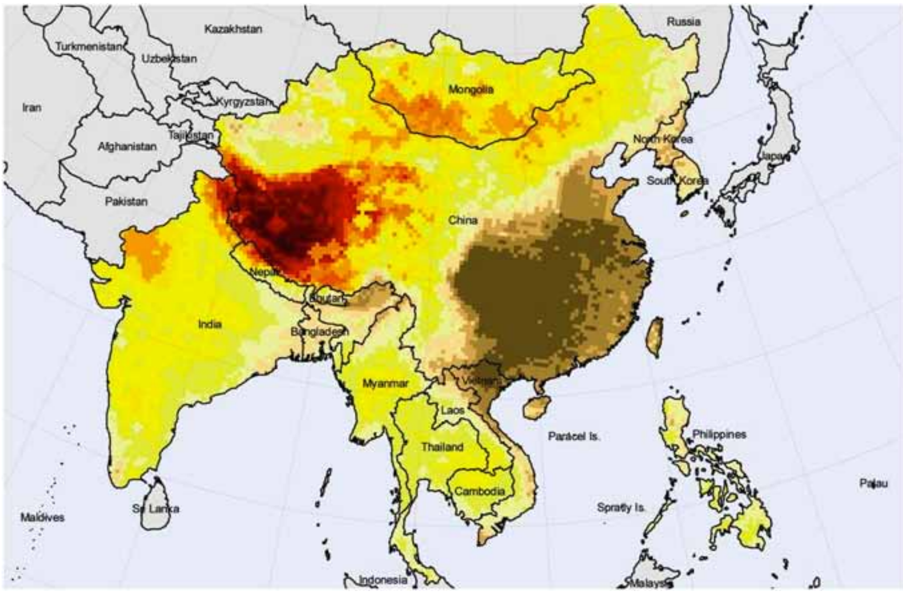
Figure 58 Solar and Wind Energy Resource Assessment in Brazil – SWERA Project Report



Solar and Wind Energy Resource Assessment in Brazil – SWERA Project Report	Free
Author/Publisher	INPE/CEPEL
Resolution	10km x 10 km Data acquired at airports, automatic weather stations and SONDA network sites used for validation – Mesoscale ETA model for wind maps
Link to publication	http://sonda.ccst.inpe.br/publicacoes
	– Report with long-term potential for large scale use of solar and wind energies in Brazil. – High quality information on solar and wind energy resources; along with tools to facilitate energy policies and investments

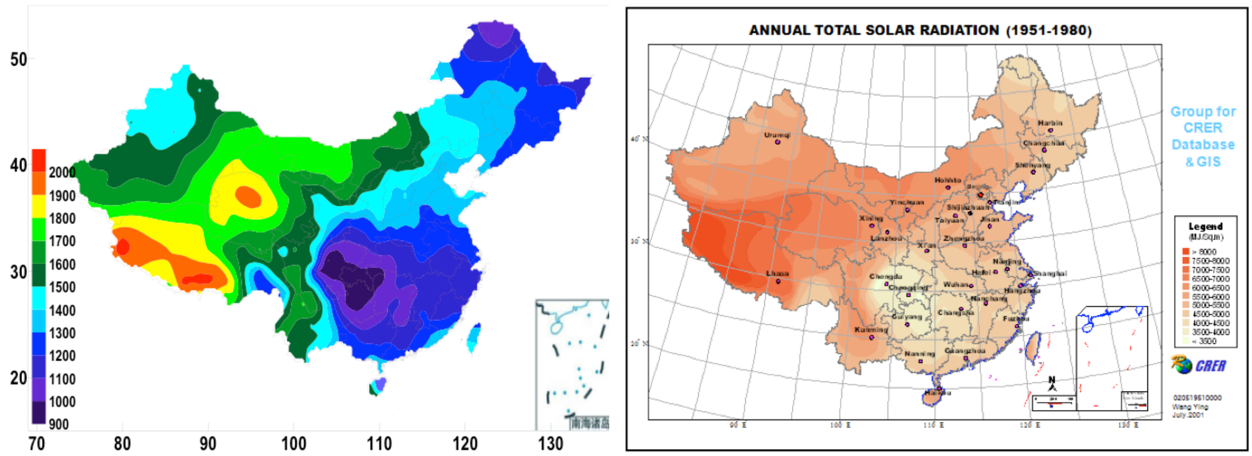
Available Solar and Wind Resource Assessments in China

Figure 59 Solar and Wind Energy Resource Assessment in China – SWERA Project



	Free
Author/Publisher	UNEP/NREL
Resolution and Methodology	East Asia Coverage- Low resolution map collection (40km) – Wind power density maps at 50 m height -Combination of analytical, numerical and empirical methods
Link to publication	http://swera.unep.net
	Model estimates monthly average daily total radiation using inputs derived from satellite and surface observations of cloud cover, aerosol optical depth, precipitation water vapour, albedo, atmospheric pressure and ozone sampled (2006).

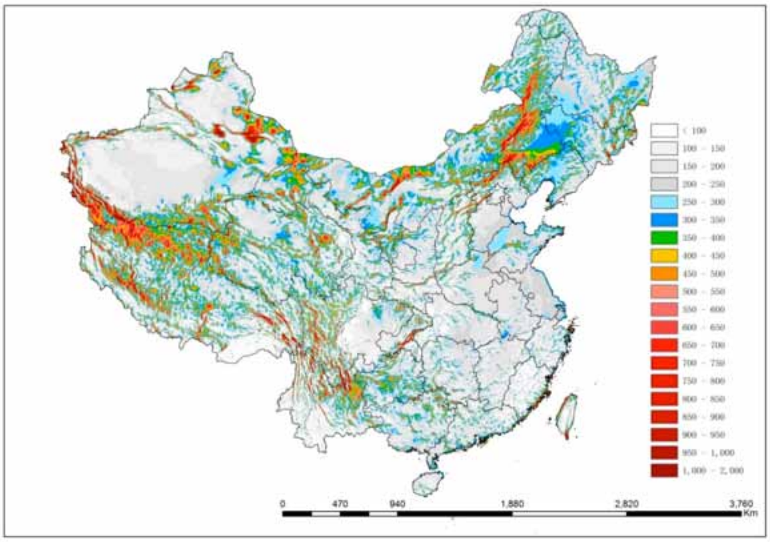
Figure 60 Solar Resource Assessment for China



"GIS of wind and Solar for China" UNEP project titled "Capacity Building of Rapid Commercialization of Renewable Energy in China". ERI et al 2000-2001.

Solar Resource Assessment for China	
Author/Publisher/Sponsor	ERI/China National Weather Bureau/Energy Research Institute-NDRC
Resolution and Methodology	– Low resolution map collection
Link to publication	
Main Findings	Map based on the data of solar radiation from 1951-1980, very low resolution

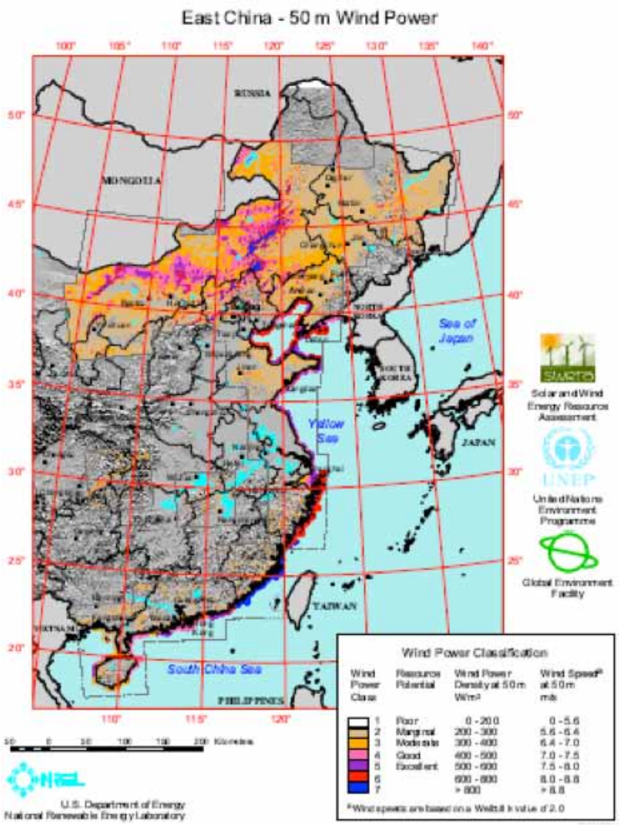
Figure 61 China Wind Resource Assessment Report – NDRC



Wind resources density of China (unit: w/m^2, 70m height, 1978-2008, resolution 1km×1km)

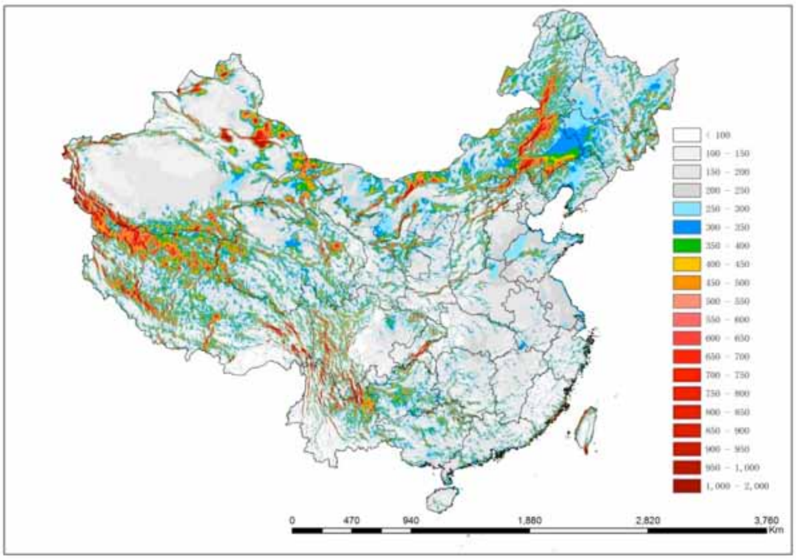
China Wind Resource Assessment Report – NDRC	
Author/Publisher/Sponsor	National Development and Reform Commission (NDRC)
Resolution	50W/m^2 Data acquired at airports, automatic weather stations and SONDA network sites used for validation
Link to publication	Book-wind resource maps and report

Figure 62 China Wind Energy Resource Mapping Activity – UNEP

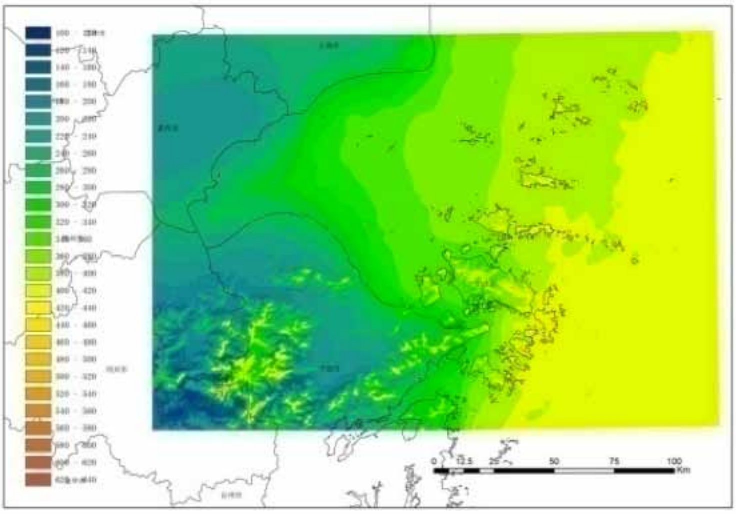


China Wind Energy Resource Mapping Activity – UNEP	Free
Author/Publisher/Sponsor	UNEP-NREL/GEF
Resolution	1kmx1km
Link to publication	http://swera.unep.net
Findings/Areas covered	Eastern China including offshore areas

Figure 63 National Wind Energy Resource Detailed Assessment – NRDC



Wind resources density of China (unit: w/m², 70m height, 1978-2008, 1km×1km)



Wind resources density of Hangzhou Bay of China (unit: w/m², 70m height, 1978-2008, resolution 200m×200m)

China Wind Energy Resource Mapping Activity – UNEP	Free
Author/Publisher/Sponsor	National Development Reform Commission/Ministry of Finance
Resolution	1kmx1km and 200mx200m Numerical modelling, mesoscale model, 400on-site measurements
Link to publication	n/a
	Aims to find potential sites for 50 GW wind farms: – Onshore wind theoretical potential is 3800 GW – Onshore wind technical potential of 2,380 GW (50 m height). – Offshore wind technical potential of 400 GW (depth ≤50m)

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About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

> sustainable consumption and production
> the efficient use of renewable energy
> adequate management of chemicals,
> the integration of environmental costs in development policies

The Office of the Director, located in Paris, coordinates activities through:

> **The International Environmental Technology Centre** - IETC (Osaka), which implements integrated waste, water and disaster management programmes, focusing in particular on Asia.
> **Sustainable Consumption and Production** (Paris), which promotes sustainable consumption and production patterns as a contribution to human development through global markets.
> **Chemicals** (Geneva), which catalyses global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.
> **Energy** (Paris and Nairobi), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.
> **OzonAction** (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.
> **Economics and Trade** (Geneva), which helps countries to integrate environmental considerations into economic and trade policies, and works with the finance sector to incorporate sustainable development policies.

UNEP DTIE activities focus on raising awareness, improving the transfer of knowledge and information, fostering technological cooperation and partnerships and implementing international conventions and agreements.

For more information,
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UNEP

This report documents crucial information to support deployment of renewable energies in three key emerging markets – Brazil, China and South Africa – and provides information for policy-making aimed at supporting renewable energy markets in these countries. Specifically this study collates information on solar and wind resources and resource information, renewable energy support policies and goals, risk management and technologies integral to the increased renewable energy technology deployment.

DTI/1459/PA